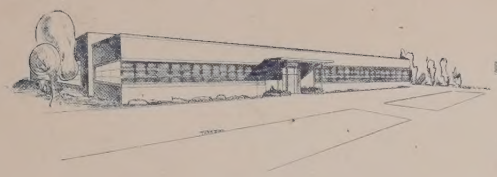


INDUSTRIAL AND NUCLEAR INSTRUMENTS

ANALOG COMPUTERS

Berkeley *division*

BECKMAN INSTRUMENTS, INC.
2200 WRIGHT AVE., RICHMOND, CALIF.
TELEPHONE: LANDSCAPE 6-7730

WARNING

Do not attempt to operate this instrument until you have read the Instruction Manual.

INSTRUCTION MANUAL

Model 1011
POWER SUPPLY

BERKELEY division of
Beckman Instruments, Inc.

Richmond 4, California
30 Sept. 1955

WARRANTY

Every instrument manufactured by the BERKELEY division of Beckman Instruments, Inc. is warranted to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes, fuses and batteries, which shall within one year from date of shipment to the original purchaser prove to be defective after our examination.

Instruments to be repaired must be returned to the factory with transportation charges prepaid. Repair work will be performed only upon receipt of a written purchase order or authorization. Repaired instruments will be returned to the purchaser with transportation charges collect.

Claims for damage in shipment should be filed promptly with the transportation company. All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing.

Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, BERKELEY division of Beckman Instruments, Inc., Richmond 4, California.

Model 1011 Power Supply

DESCRIPTION

The Model 1011 supplies regulated power at +250 volts, -250 volts, and -465 volts. These voltage sources will supply:

1. One Model 1041 Operational Amplifier Chassis with ten Model 1048 Amplifier and two Model 1070 Function Generators.

or

2. One Model 1041 with ten Model 1048 Amplifiers and one Model 1071 Function Generator

or

3. Five Model 1071's

Both plus and minus 250 volt sources are electronically regulated. An improved transient-filtering system eliminates the need for chokes and substantially reduces the weight and bulk on the unit. The -465 volt source supplies only the output stage of the 1048 Operational Amplifiers. It is regulated satisfactorily by VR tubes. Separate plate and filament transformers are energized by individually fused a-c lines. Indicator lamps on the front panel light to indicate blown fuses. Output voltage and regulation adjustments are also on the front panel.

SPECIFICATIONS

Input	
Filament	115v,50-60 cps, 150 watts
Plate	115v, 50-60 cps, 140 watts.
Output	+250 volts, 300 ma maximum
	-250 volts, 150 ma maximum
	-465 volts, 55 ma maximum

Regulation	Ripple below 10 millivolts on both 250 volt supplies.

INSTALLATION & INITIAL ADJUSTMENTS.

Normally the plate and filament a-c input cords are plugged into the plate and filament a-c lines along the back of the "EASE" * Computer rack. Adjust the 250 volt sources from the front panel. First connect a voltmeter and a high gain oscilloscope to the red -250 volt jack. Adjust the VOLTAGE CONTROL on that side of the panel until the meter reads 250 volts. Then adjust the adjacent REGULATION control until the scope shows minimal ripple. Adjusting one control will affect the other slightly so the adjustments will probably have to be repeated. Adjust the +250 volt supply in the same way.

A potentiometer on the top of the chassis labelled " -460 LOAD" adjusts the -465 volt supply for best regulation. It is calibrated in terms of the number of Model 1048 Amplifiers the unit supplies. To obtain regulation which is ordinarily adequate, simply turn the pointer to the number of Model 1048's served. To obtain the best regulation possible place the operating load on the power supply and plug a milliammeter into J107, a two terminal jack on the chassis rear. Adjust the potentiometer for a reading of 18 ma.

CIRCUIT DESCRIPTION

-465 volt Supply

This supply is obtained from one side of the plate transformer secondary which also generates the -250 volt supply. The a-c voltage is applied to a half-wave selenium rectifier (CR 102 to 104) and the d-c output is R-C filtered and held constant with respect to the -250 volt source by two VR tubes in series (V116 and V117). The regulated output is available at J104 and Pin 6 of both J105 and J106. The -465 volt source is also used internally in the Model 1011 to provide a bottom potential for the negative-feedback d-c amplifier in the -250 volt regulating system. The voltage is independently regulated by another pair of VR tubes (V113 and V114).

* Trademark

A reference voltage for the -250 volt regulating system is obtained by dropping the bottom potential through R139. The resulting voltage is held 86 volts below the -250 volt source by V115, a 5651 VR tube.

The -250 Volt Supply

This supply voltage is obtained from V103, a 5U4G full wave rectifier. The d-c output of the rectifier is series regulated by a negativefeedback system (V109 to V112). The load current passes through two parallel-connected 6080 tubes (V109 & V110). The voltage drop across these tubes is controlled by their grid potential in such a way as to maintain a constant output supply voltage. The control mechanism may be understood by considering V111, V112 and the 6080 tubes as an intergral high-gain amplifier with negative feedback. See Figure 1. The voltages in parenthesis on the figure are those which would exist if the -250 volt bus were grounded instead of the cathodes of the 6080 tubes, that is, considering the -250 volt line as ground potential. The fixed input potential (e_i) maintained by the VR tube is -86 volts. The input resistance (R_i) is R136 plus a part of R135. The feedback resistance (R_o) is R134 plus the other part of R135. The equation describing such an amplifier is

$$e_o = - e_i \frac{R_o}{R_i}$$

Since e_i is constant, e_o remains constant at a value determined by the ratio of R_o to R_i. When R135 (the VOLTAGE CONTROL potentiometer) is adjusted properly the ratio is about 3 to 1 and e_o is stable at +250 volts. The REGULATION potentiometer (R122) adjusts the system for most senstive regulation by setting the positive feedback ratio of V111, thus maximizing the gain of the regulation amplifier.

The +250 volt Supply

This supply is generated and regulated in the same way as the -250 volt supply. However, the input voltage to the regulating amplifier is the output voltage of the -250 volt supply so it depends upon this supply for its accuracy and regulation. (See Figure 2).

MAINTENANCE

In case of trouble check tubes first. Faulty tubes can often be spotted visually. If all the tubes prove to be satisfactory, check the amplitude and regulation of the three supplies. Keep in mind that the +250 volt supply depends upon the -250 volt supply and this in turn on a part of the -465 volt supply. Make the following tests in the order listed:

1. Examine the -465 volt output at J103 and J104. Low or poorly regulated voltage at these points may indicate defective selenium rectifiers (CR 102 to 104) or open filter resistors.
2. Examine the -250 volt output at the red front panel jack. If the voltage is absent or poorly regulated under load, check the components associated with the rectifier (V103) and the 6080 tubes (V109 & V110). If the VOLTAGE CONTROL adjustment has no effect on the output voltage check components associated with V111 and V112.
3. Examine the +250 volt output at the red front panel jack. If the voltage is absent or poorly regulated under load, check the components associated with the two rectifiers (V101 and V102) and the three 6080 tubes (V104 to 106). If the VOLTAGE CONTROL adjustment has no effect on the output voltage check the components associated with V107 and V108. The grids of the 6080 tubes are at the plate potential of the triode half of V107. This plate voltage is supplied by an independent rectifier-filter system including CR101 and R101. Failure of either of these components will remove the positive charge from the grids of the 6080 tubes and cause the output voltage to drop very low.

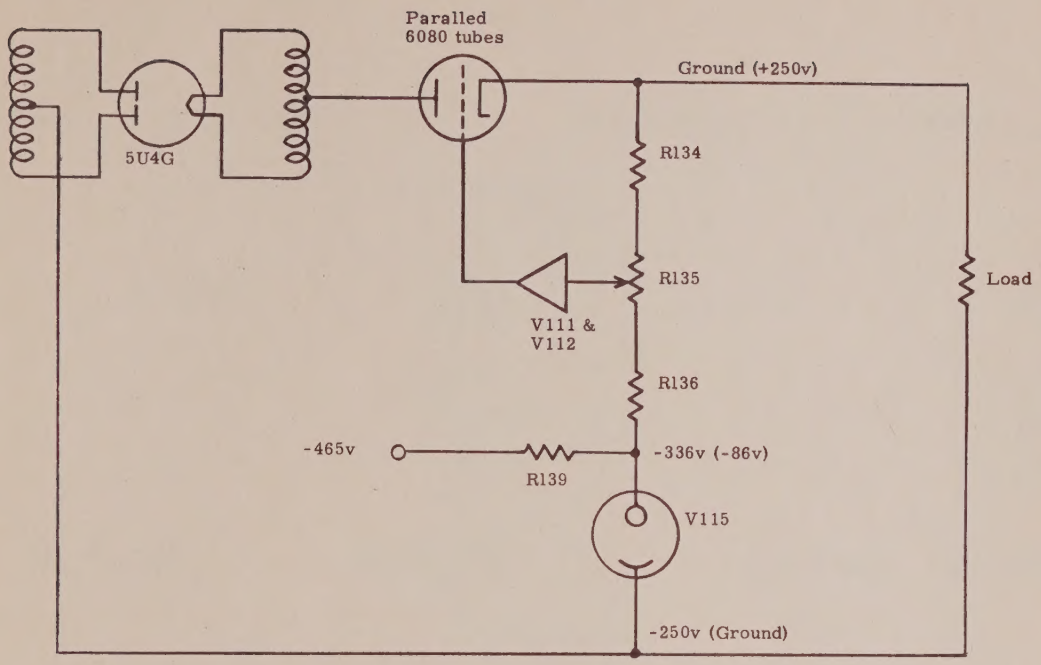


FIGURE 1 -250 VOLT REGULATING SYSTEM
MODEL 1011

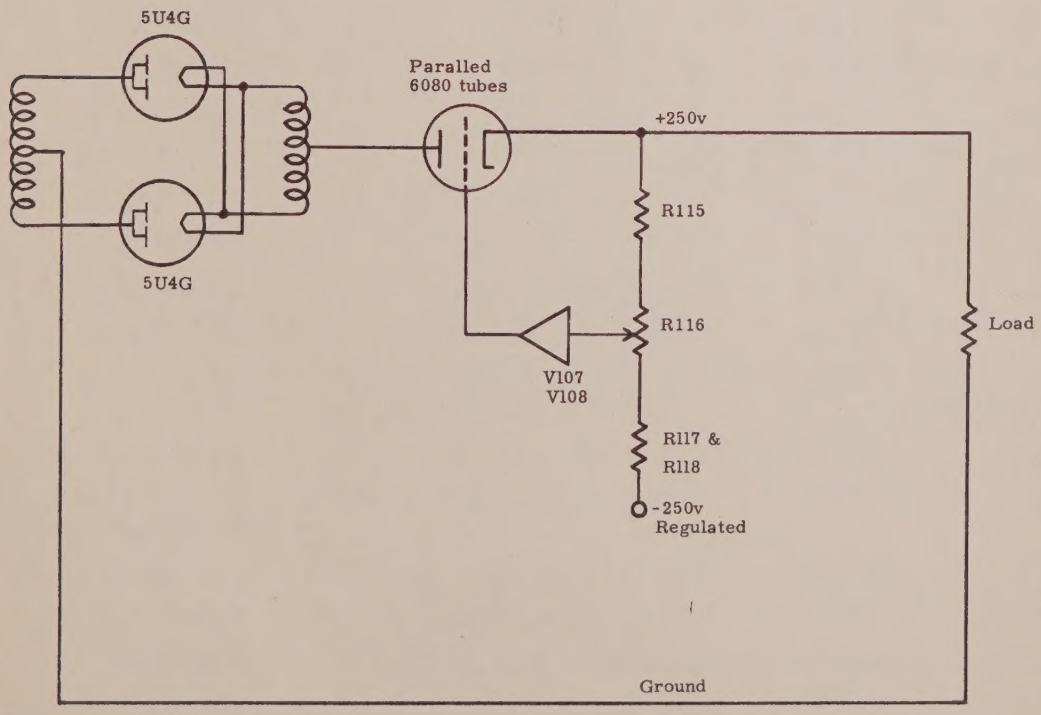


FIGURE 2 +250 VOLT REGULATING SYSTEM
MODEL 1011

PARTS LIST

TUBES

Type	Quantity	Type	Quantity
5U4G	3	12AX7	2
6080	5	OB2	4
6U8	2	5651	1

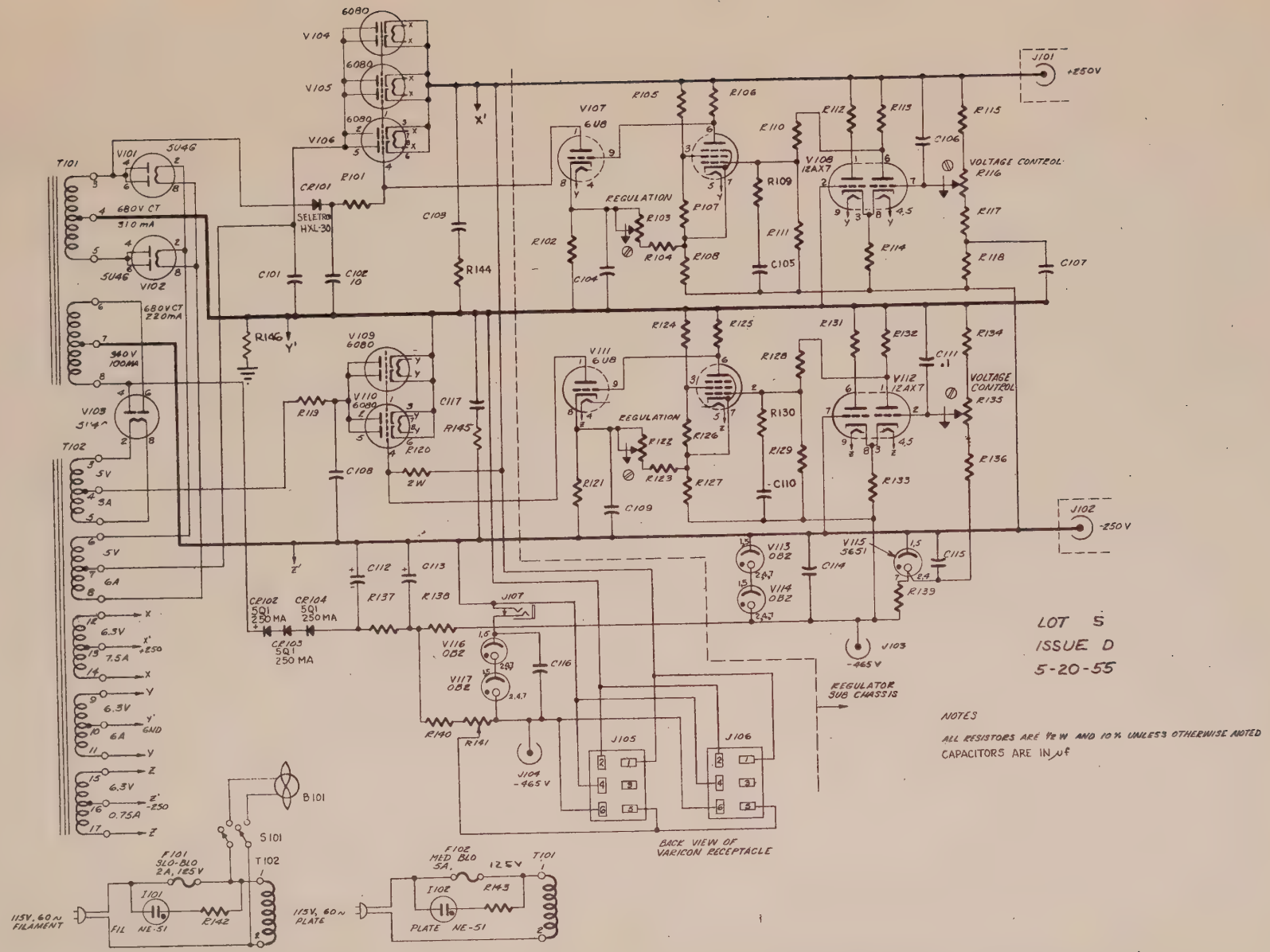
RESISTORS

Detail No.	Stock No.	Description	Mfr. & No.
R101	1-2802	150K, 2 W, 10%	AB HB 1541
R102	1-1120	4.7 K, 1W, 10%	AB GB 4721
R103	1-1340	Potentiometer 100K, 2W Linear	AB JU 1041
R104	1-1124	22K, 1W, 10%	AB GB 2231
R105	1-0248	47K, 2 W, 10%	AB HB 4731
R106	1-1131	220K, 1 W, 10%	AB GB 2241
R107	1-1575B	33K, 2 W, 5%	AB HB 3335
R108	1-0688A	22K, 2 W, 5%	AB HB 2235
R109	1-0208	6.8K, 1/2 W, 10%	AB EB 6821
R110	1-3134	1.8 M, 1/2 W, 5%	AB EB 1855
R111	1-0798A	1.5 M, 1/2 W, 5%	AB EB 1555
R112, R113 & R114	1-1856	470 K, 1/2 W, 5%	AB EB 4745
R115	1-3289	240 K, 1W, 1%	Electra DC-1
R116	1-5708	Potentiometer 25K, WW, 3 W	A: 3/8; B:3/8 no flats Clarostat Type 58-25000
R117	1-5729	90K, 1/2 W, 1%	Electra DC-1/2
R118	1-3361	150 K, 1/2 W, 1%	Electra DC-1/2
R119	1-5855	50 Ohm, 5 W, 10% WW	Tru Ohm
R120	1-5710	220 K, 2 W, 10%	AB HB 2241
R121		Same as R102	
R122	1-2169	Potentiometer 25K, 2 W, Linear	

Detail No.	Stock No.	Description	Mfr. & No.
		RESISTORS	
R123	1-1123	18 K, 1 W, 10%	
R124		Same as R105	
R125		Same as R106	
R126		Same as R107	
R127		Same as R108	
R128		Same as R110	
R129		Same as R111	
R130		Same as R109	
R131, R132 R133		Same as R112	
R134		Same as R115	
R135		Same as R116	
R136	1-5046	75 K, 1/2 W, 1%	Electra DC- 1/2
R137	1-0998	1 K, 10 W, 10% WW	Ohmite
R138	1-1044	5 K, 10W, WW	Model Eng.
R139		Same as R105	
R140	1-5825	1750 Ohm, 20 W, 10% WW	Tru Ohm
R141	1-5711	5 K, 25 W, WW	Ohmite 0162
R142	1-0219	180 K, 1/2 W, 10%	AB EB 1841
R143		Same as R142	
R144	1-3607	10 Ohm, 1/2 W, 10%	AB EB 1001
R145		Same as R144	
R146	1-0210	10 K, 1/2 W, 10%	AB EB 1031
		CAPACITORS	
C101	2-5712	20 Mdf, 600 V, W/Mtg. Brackets	Sangamo 7106-20
C102	2-0703	10 Mfd, 600 V, W/Mtg. Brackets	National CP70B1E F106K
C103	2-2179	1, Mfd, 400 V	Sangamo 30410

Detail No.	Stock No.	Description	Mfr. & No.
		CAPACITORS	
C104	2-1950A	.02 Mfd, 600 V	Sangamo 30612
C105	2-1760	.001 Mfd, 500 V	Sangamo K 1210
C106	2-0763	.1 Mfd, 400 V	Sangamo 300401
C107	2-3835	0.5 Mfd, 400 V	Sangamo Type 30 300405
C108		Same as C101	
C109		Same as C104	
C110		Same as C105	
C111		Same as C106	
C112	2-1675	80 Mfd, 450 V	Sangamo PL 4580
C113		Same as C112	
C114	2-1957	.05 Mfd, 400 V	Sangamo Type 30 300615
C115		Same as C104	
C116		Same as C106	
C117		Same as C103	
		OTHER COMPONENTS	
B101	9-3390	Fan Motor	General Industries A-5-CW
CR101	8-5713	Rectifier	Seletron HXL-30 (only)
CR102	8-1285	Rectifier 250 MA 5Q1	Radio Receptor Co,
CR103		Same as CR102	
CR104		Same as CR102	
F101	7-0504A	Fuse 2A-125V Slo Blo	Littlefuse
F102	7-277A	Fuse 5A-250 V Med Blo	Littlefuse #312005
I101	21-1679	Pilot Lamp	NE-51
I102		Same as I101	

Detail No.	Stock No.	Description	Mfr. & No.
		OTHER COMPONENTS	
T101	6-5719	Transformer Plate 680V CT, at 310 MA, DC, 680V at 220 MA DC, CTat 340 V at 100 MA DC	Electro E 8985
T102	6-5720	Filament Transformer 6.3V at 6.A 6.3V at.75A 5V at 3A; 5V at 6A; 6.3V at 7.5A	Electro E 8977



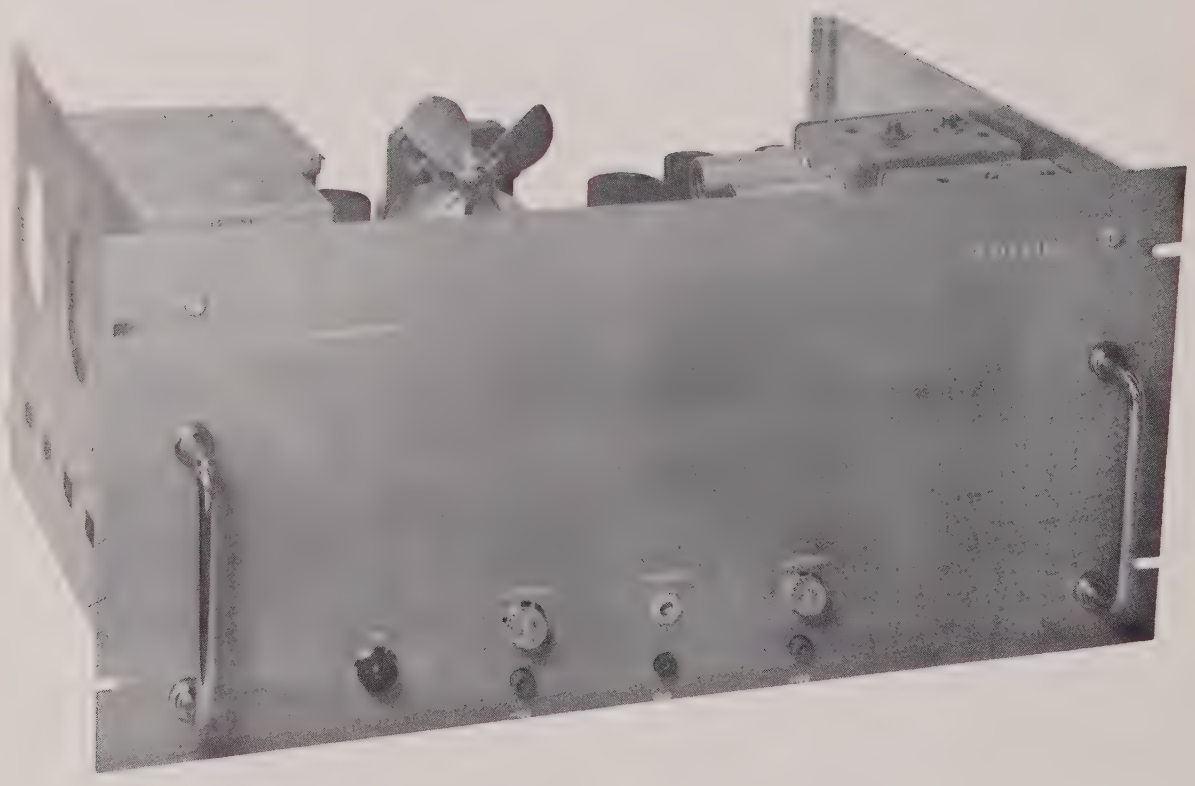
Model 1011 Schematic

INSTRUCTION MANUAL

Model 1015
POWER SUPPLY

BERKELEY division of
Beckman Instruments Inc.

Richmond 4, California
30 Sept. 1955



Model 1015 Power Supply

DESCRIPTION

The Model 1015 Power Supply furnishes extremely accurate and reliable reference voltages of +100 and -100 volts. These voltages are used to insert constants at points in a problem-solving circuit, to set the coefficient potentiometers in the control unit, to bias diodes in the 1071 Function Generator and to provide a voltage source for other uses in which accuracy is important. The positive and negative sources will each provide 150 milliamperes. When higher currents must be drawn, the Model 1015 may be supplemented by the Model 1016 Reference Slave Supply, which boosts the maximum current to 1.15 amperes from each source.

Each 100 volt supply is regulated by a Model 1048 operational amplifier. The unit generates three other regulated supply voltages (+250 -250 and -465 volts) solely for the purpose of powering the amplifiers. All supply voltages, as well as output and ground currents, may be monitored with a meter on the front panel. When one of the operational amplifiers overloads a neon lamp on the front panel lights, indicating faulty regulation. At the same time relay contacts connected to the control unit close, so that the overload warning appears there too.

The output voltages are available at four Varicor receptacles at the rear of the chassis. Three are 4-terminal connectors which carry +100 volts at two terminals and -100 volts at the other two. The fourth is a 6-terminal receptacle for connecting Model 1032 Control Unit.

SPECIFICATIONS

Input	105 to 125 volts, 60 cps
Output	+100 volts at 150 ma -100 volts at 150 ma
Accuracy of output voltage	Better than ± 0.1 volts.

OPERATION

NOTE: See the installation section of the computer manual to learn how to install the Model 1015.

To energize the power supply turn on the FILAMENT toggle switch at the bottom of the computer rack and allow the tubes to warm up one minute. Then turn on the PLATE switch. The OVERLOAD indicators will light immediately and remain lit for about half a minute. When these lights go out, the 100 volt outputs are accurate to within one tenth of a volt.

The rotary switch on the front panel connects the meter to indicate various supply voltages and currents. At the +100 position of the switch the meter indicates the output of the +100 volts supply on a 150 volt scale. At -100 it indicates the -100 volt supply voltage on the same scale. At the +250 -250 and -465 positions the meter indicates that these supply voltages are adequate if the pointer stops near the red line.

For current readings the meter scale is calibrated in milliamperes. Make these readings after the power supply has been loaded. At the +I position the meter measures the current drawn from the +100 volt supply.

At the - I position it indicates the current drawn from the -100 volt supply. At GND I + and GND I - the meter measures the current in the ground return line common to both 100 volt supplies. This current is the difference between the current drawn from the +100 volt supply and that drawn from the -100 volt supply. It may flow in either direction. If the +100 volt current is the greater the meter will read on scale when the switch is at GND I +. If the -100 volt current is thegreater the meter will read on scale at GND I -.

The 100 volt supply voltages are available at the read jacks on the front panel labelled " -100" and "+100". The OVERLOAD lamp above each jack will light when the Model 1048 amplifier which regulates that supply is overloading. This indicates that that supply is not properly regulated.

CIRCUIT DESCRIPTION

Each of the 100 volt supplies is regulated by a Model 1048 operational amplifier which plugs into a socket on the chassis. A compound referencing system is used. The -100 volt output is referred to a 10.8 volt mercury battery and the +100 volt output is referred in turn to the -100 volt output. Three other supply voltages are generated solely to power the two operational amplifiers. The -465 volt supply is adequately regulated by VR tubes. The -250 volt supply is electronically regulated by a voltage comparison circuit referred to a VR tube. The +250 supply is regulated by a high gain amplifier referred to the -250 volt supply. The circuitry is most easily under stood by considering each supply and its regulating system separately.

The 100 volt Supplies

Figure 1 is a simplified diagram of the -100 volt regulating system. The load current passes through the parallel-connected triodes (V104). The voltage drop across these triodes is controlled by varying their grid potential in such a way as to maintain a constant output supply voltage. The circuit from the input of the Model 1048 amplifier through V105, V104 and V103 to the center tap of the rectifier plate winding may be considered as a single high gain (operational) amplifier. The input and feedback connections cause it to function as a summing amplifier. Since the input voltage (e_i) is fixed at +10.8 volts the output voltage (e_o) must remain fixed at a value determined by the formula:

$$e_o = - \frac{R_o}{R_i} e_i$$

Where R_o is the feedback resistor and R_i is the input resistor. R_i is adjusted by varying R111 to a value which causes e_o to equal -100 volts.

Figure 2 is a simplified diagram of the +100 volt regulating system. It operates in the same way as the -100 volt system except that the input to the high gain d-c amplifier is the regulated -100 volt supply and no inverter and cathode follower stage is used. R107 is adjusted so that the ratio R_o / R_i will equal 1 causing e_o to equal +100 volts.

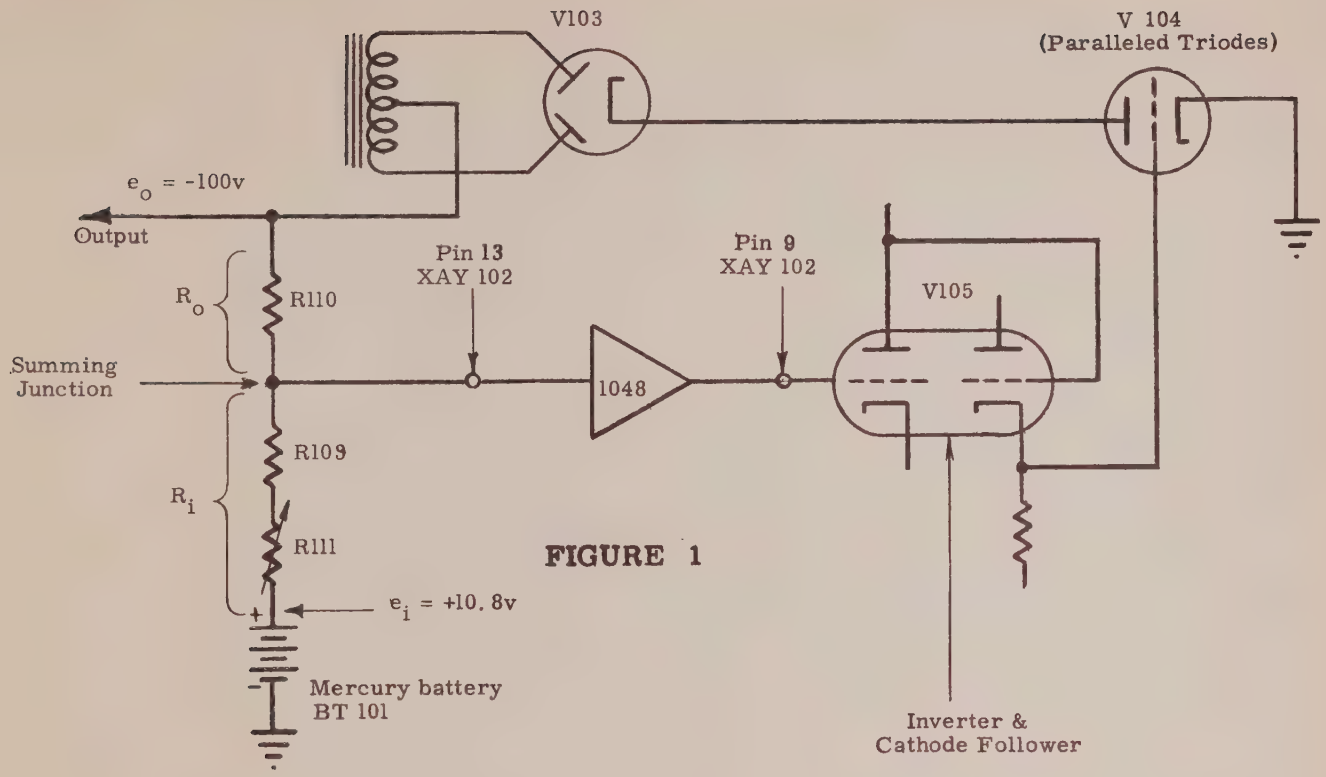


FIGURE 1

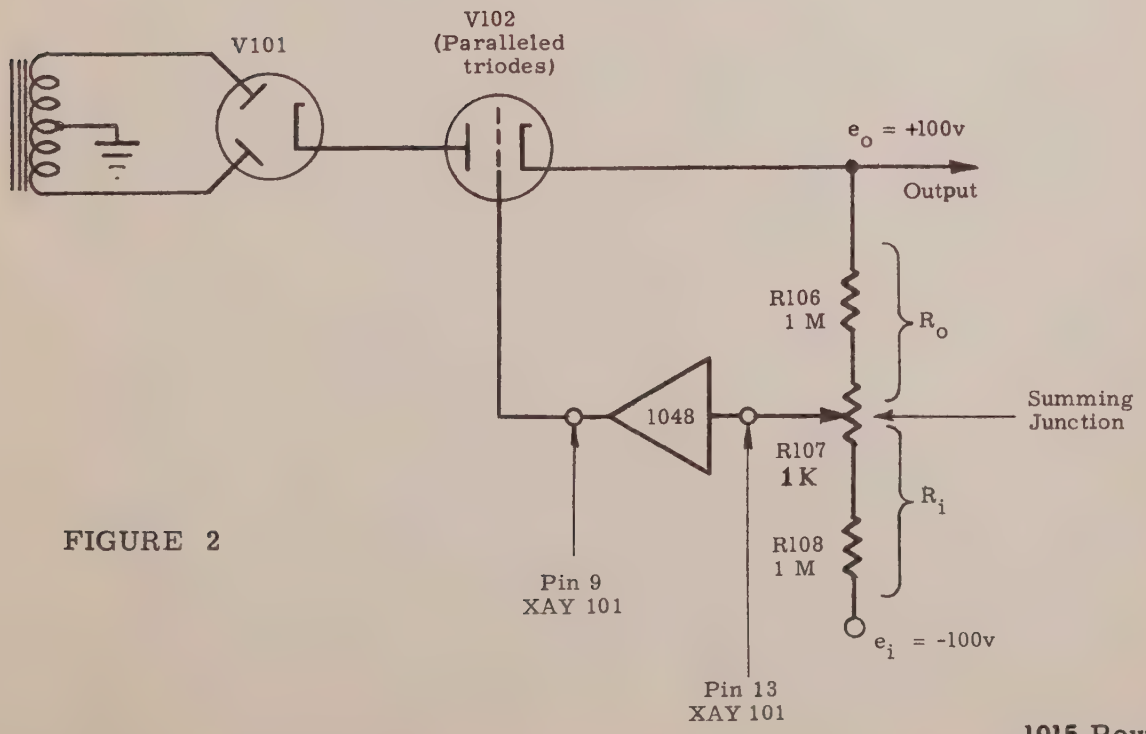


FIGURE 2

Power Supplies for the Model 1048 Regulating Amplifiers

Figure 3 is a simplified diagram of the -250 volt regulating system. The load current passes through the parallel connected triodes (V108). The voltage drop across these triodes is varied by a signal at their grids in such a way as to maintain a constant output supply voltage. The grid signal is supplied by V109 which operates as a voltage comparison tube. Its cathode is held 87 volts positive of the output voltage by the VR tube V113. Its grid picks up a fraction of the output voltage from the junction of R134 and R136. When the output voltage varies, the potential difference between the grid and cathode varies in a direction which creates an output signal at the plate of V109 tending to cancel the variation. Since the gain of V109 is about 2000, the regulation is very good.

Figure 4 is simplified diagram of the +250 volt regulating system. The circuit is like the -100 volt regulating system except that a single high gain tube (V107) takes the place of the Model 1048 amplifier and both e_i and e_o are approximately 250 volts instead of 100 volts.

The -465 volt supply is drawn from the same transformer winding that creates the -250 volt supply. The a-c voltage is half wave rectified by CR 105B and CR 106, filtered by C110 and C111 and regulated for a small current drain by two VR tubes (V111 and V112).

Meter Circuitry

At the +100, -100, +250, -250 and -465 positions the rotary switch on the front panel connects the meter (and appropriate resistors in series with it) between each of the five supply voltages and ground. At the +I position the switch shunts the meter across a 10 ohm resistor in the +100 volt output line. At the -I position it shunts the meter across a similar resistor in the -100 volt output line. At the GND I + and GND I - positions the meter is shunted across a 10 ohm resistor in the ground current

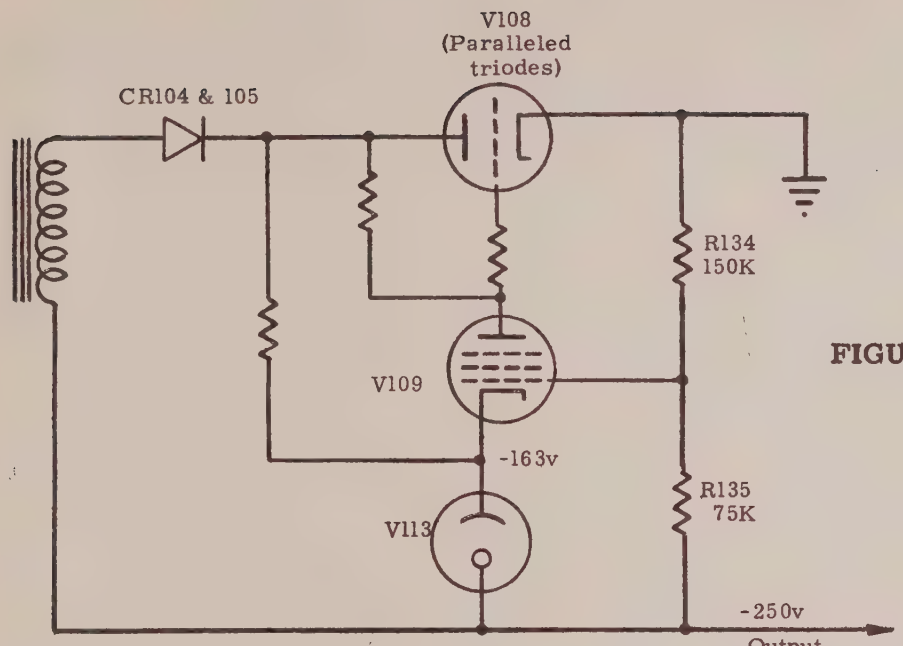


FIGURE 3

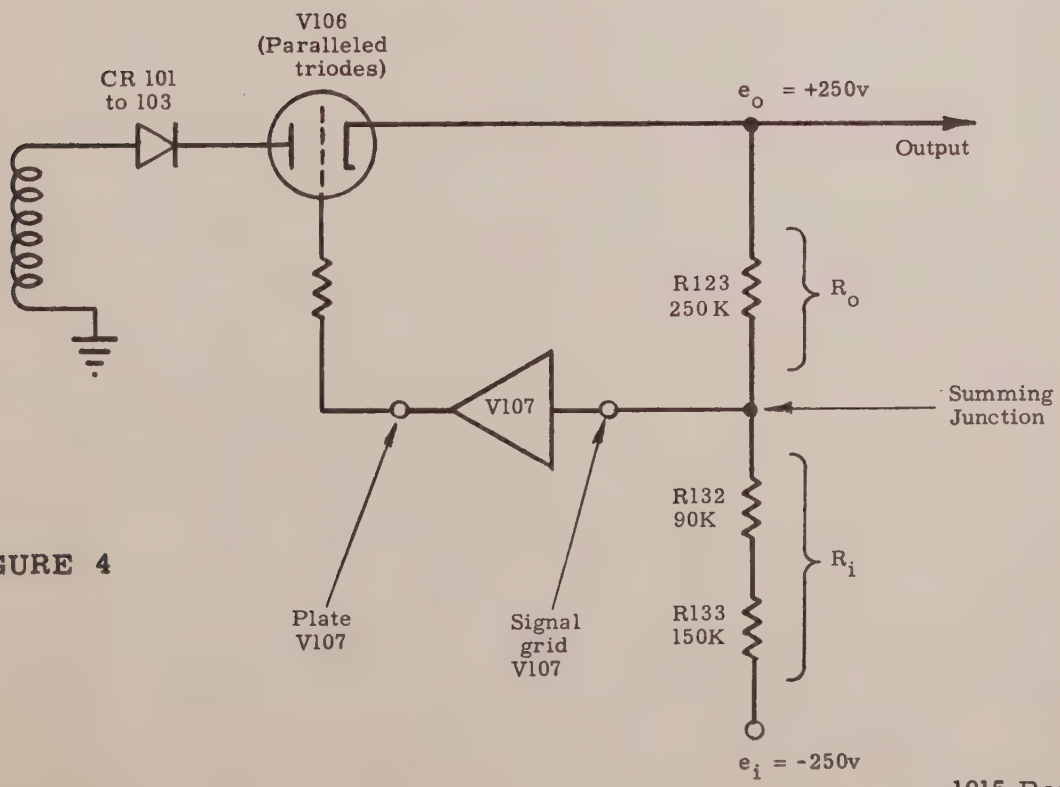


FIGURE 4

return common to both +100 and -100 volt supplies. The current flowing in this resistor is the difference between the currents drawn from the 100 volt supplies and it may flow in either direction. Two positions are provided so that the meter may be connected in the proper polarity.

OUTPUT ADJUSTMENTS

The adjustments of the outputs consist of setting the negative reference at -100 volts and balancing the positive and negative references so that their algebraic sum equals zero. Set the negative reference in the following manner: At the Reference Supply front panel, position the rotary switch at -100 and turn the VOLTAGE ADJustment until the meter reads 100. After this setting is completed, both outputs are balanced as follows: Connect the circuit shown in figure 5 to the jacks on the front panel of the Reference Supply. The amplifier is a standard operational amplifier, available at the computer patch board. The meter is the Control Unit front panel meter with the METER SELECTOR 2V button depressed. At the Reference Supply, position the front panel rotary switch at +100 and turn the +100V ADJustment, located on the chassis between the two plug-in amplifiers, until the meter at the Control Unit reads zero. Switch positions of the 10K input resistors (figure 5), putting one in the place of the other, and again observe the Control Unit meter indication. If this differs from zero, adjust the Reference Supply +100V ADJustment to bring the meter needle back toward zero one-half the amount of the difference.

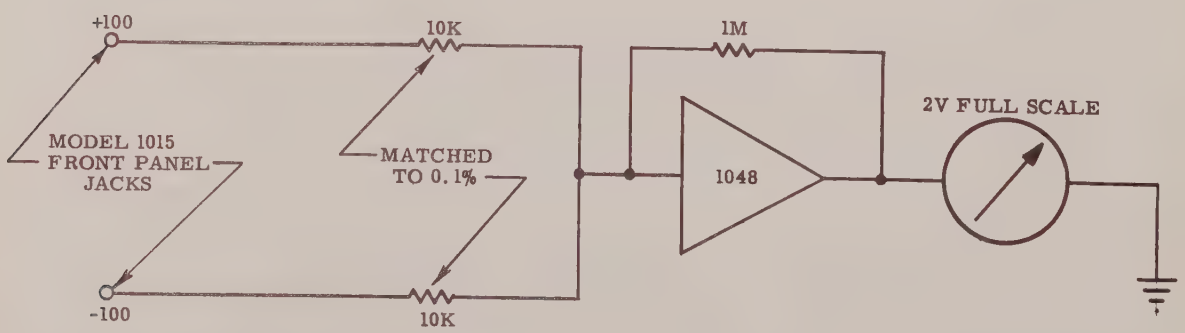


FIGURE 5

TUBES

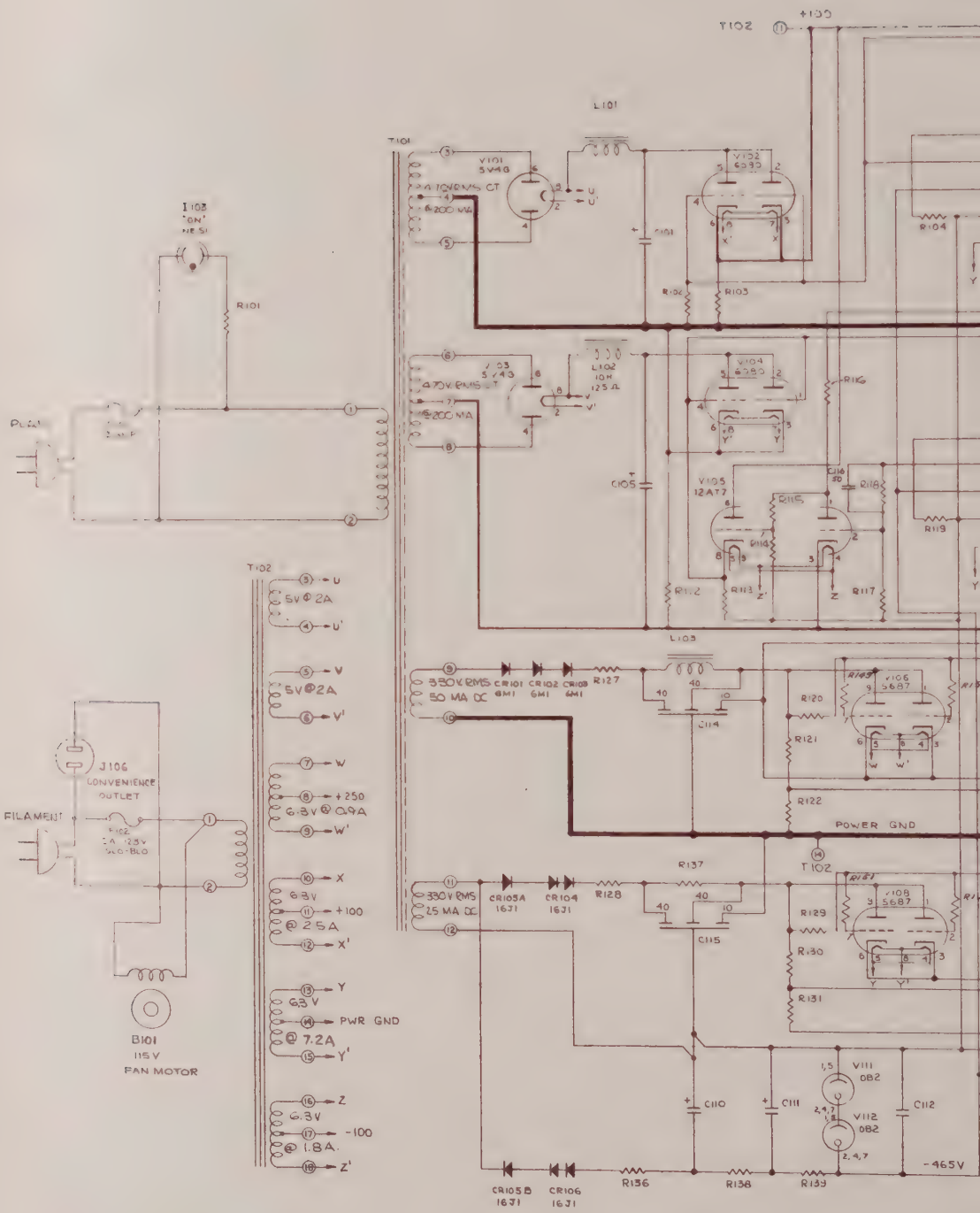
Type	Quantity	Type	Quantity
5V4G	2	6AU6	2
6080	2	5963	1
12AT7	1	OB2	2
5687	2	5651	1

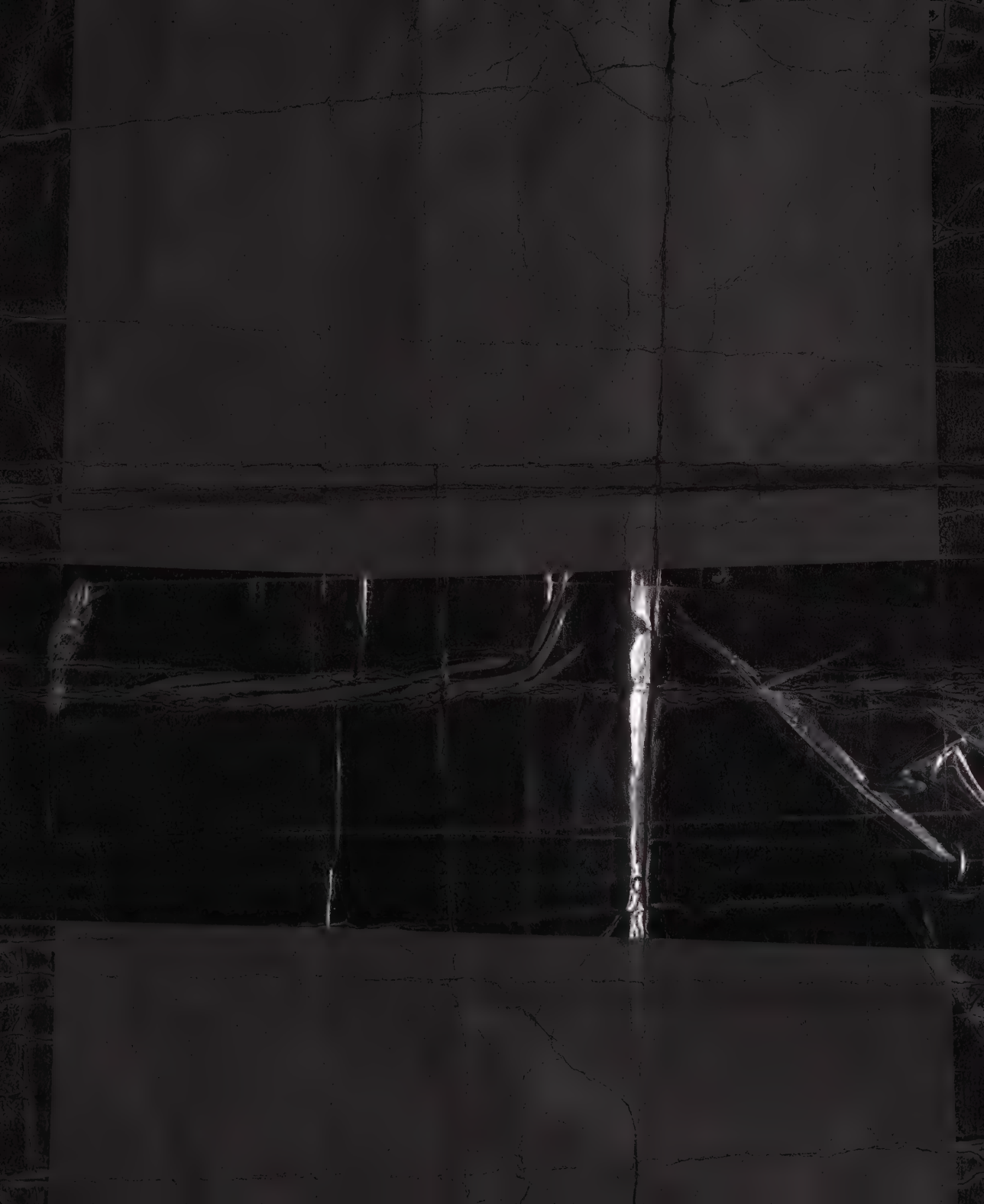
Detail No.	Stock no.	Description	Mfr. & No.
		RESISTORS	
R101	1-0219	180 K, 1/2 W, 10%	AB EB 1841
R102	1-0217	100 K, 1/2 W, 10%	AB EB 1041
R103	1-6267	5 K, 5 W, 10%	Tru Ohm
R104	1-2833	100 K, 1 W, 1% D. C.	Electra DC
R106	1-5886	1 M, 1/2 W, .05% W. W.	Daven Type 1113 Alloy Type V
R107	1-0874	Potentiometer 1 K, 2 W Linear	AB JU 1021 SD 3048
R108		Same as R106	
R109	1-5885	104 K, 1/2W, .1%, WW	Daven Type 1112 Allow Type V
R110		Same as R106	
R111	1-1343	Potentiometer 5K, 2W Linear	AB JU 5021 SD 3048
R112		Same as R103	
R113	1-0248	47 K, 2 W, 10%	AB HB 4731
R114	1-0225A	1 M, 1/2 W, 5%	AB EB 1055
R115	1-1177A	680 K, 1/2 W, 5%	AB EB 6845
R116	1-2802	150 K, 2 W, 10%	AB HB 1541
R117	1-1174A	150 K, 1/2 %, 5%	AB EB 1545
R118	1-0960	100 K, 1/2 W, 5%	AB EB 1045

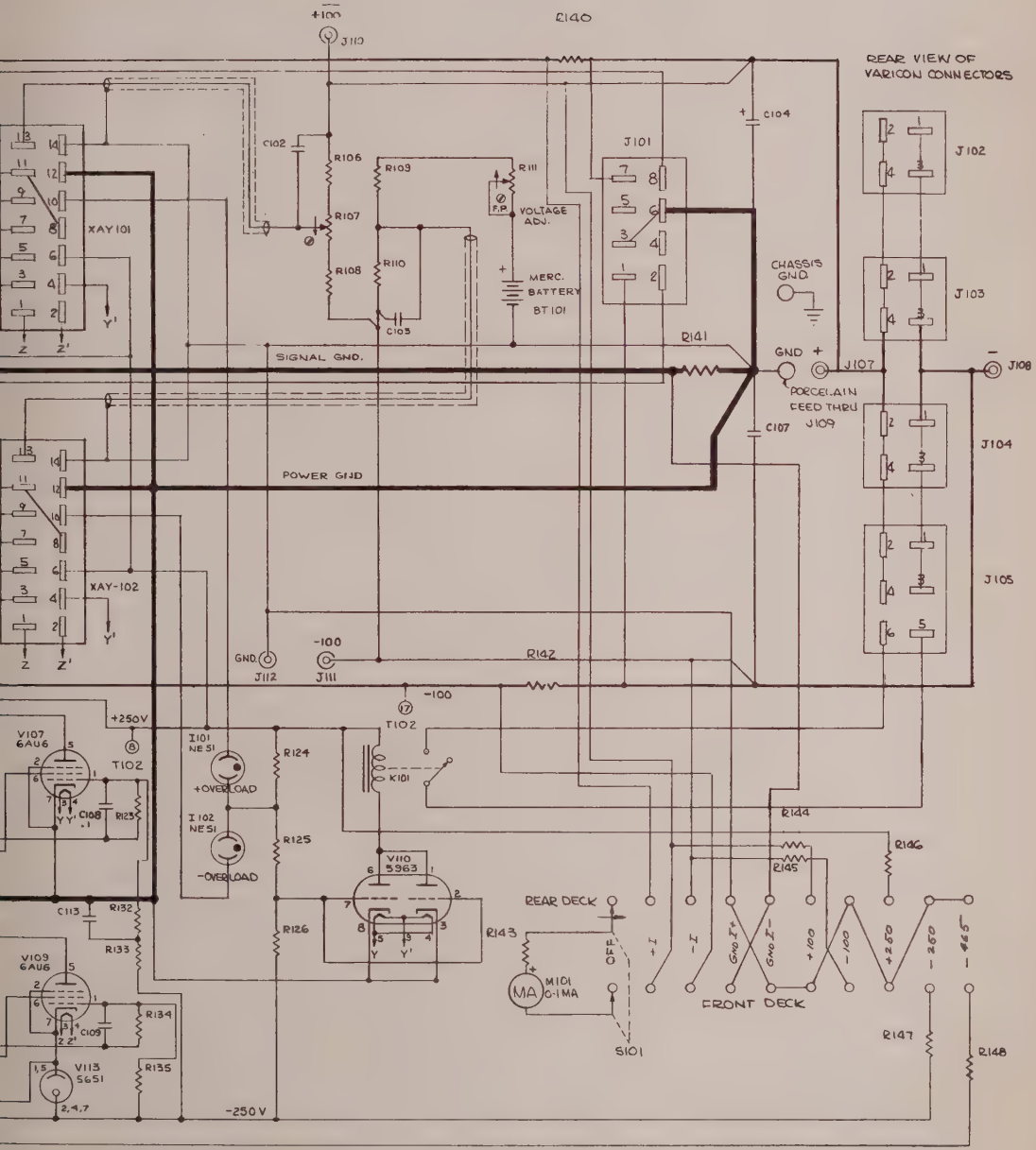
Detail No.	Stock No.	Description	Mfr. & No.
		RESISTORS	
R119		Same as R104	
R120	1-1177	680 K, 1/2 W, 10%	AB EB 6841
R121	1-0243	270 K, 1 W, 10%	AB GB 2741
R122		Same as R102	
R123	1-5887	250 K, 1 W, 1% D. C.	Electra
R124	1-0376	270 K, 1/2 W, 5%	AB EB 2745
R125	1-1101	82K, 1/2 W, 5%	AB EB 8235
R126		Same as R124	
R127	1-3607	10 Ω, 1/2 W, 10%	AB EB 1001
R128	1-1195	330hm 1/2 W, 10%	AB EB 3301
R129		Same as R120	
R130	1-1128	120 K, 1W, 10%	AB GB 1241
R131	1-1172	47 K, 1/2 W, 10%	AB EB 4731
R132	1-5729	90 K, 1/2 W, 1% D. C.	Electra DC 1/2
R133, R134	1-3361	150 K, 1/2 W, 1% D. C.	Electra DC 1/2
R135	1-5046	75 K, 1/2 W, D. C. 1%	Electra DC 1/2
R136		Same as R128	
R137	1-1112A	1 K, 2 W, 10%	AB HB 1021
R138, R139	1-2942	6 K, 10 W, 10%	Tru-Ohm
R140, R141 R142	1-5958	10 Ω 1 W, 1% WW	Brown corp. Ltd. EM-S CAL-OHM
R143	1-5959	1450 Ω, 1/4 W, 1% WW	Cinema 410N
R144, R145	1-5960	149 K, 1/4 W, 1% W. W.	Cinema 411N
R146, R147	1-5956	300 K, 1/2 W, 1% W. W.	Cinema R11N
R148	1-5957	555 K, 1 W, 1% W. W.	Cinema SW-1BN
R149, R150 R151, R152	1-3547	100 Ohm 1/2 W, 5%	ABEB 1015

Detail No.	Stock No.	Description	Mfr. & No.
		CAPACITORS	
C101	2-1965	12 μfd, 450 V DCW, Elect. Paper	Sangamo MT 4512
C102, C103	2-3086	.1 μfd, 400 V	Gudeman XF 1816
C104	2-3135	20 μfd, 250 V	Sangamo MT 2520
C105		Same as C101	
C107	2-3358	12 Mfd 250 V	Sangamo MT 2512
C108, C109	2-0763	.1 μfd, 400V, Molded Paper	Sangamo Type 30 300401
C110, C111	2-1321	40 μfd, 450 V	Sangamo PL 4540
C112	2-2150	.05 μfd, 400 V	Sangamo 300415
C113	2-3835	.5 μfd, 400 V	Sangamo 300405
C114, C115	2-3589	40-40-10 μfd, 450 V	Sangamo PLT 7415
C116	2-2141	50 Mfd 500 V	Sangamo Type RR
		OTHER COMPONENTS	
AY101, AY102	Model 1048	Amplifier	
B101	9-3390	Motor Fan	General Industries A5-CW
BT101	28-5898	Mercury Battery	Mallory Type 302908
CR101, CR102 CR103	8-1699A	Rectifier 6 M1 Selinium	Radio Receptor Co.
CR104, CR105 CR106	8-5892	16J1 Selenium Rectifier	Seletron 16J1
F101	7-5891	Fuse 3 Amp, 125 V, Med-Blo	Littlefuse 312003
F102	7-0504A	Fuse 2 Amp, 125 V, Slo-Blo	Littlefuse 313002
I101, I102 I103	21-1679	Neon Lamp 1/25 W, 105-125 V	GE NE 51
K101	16-1865	Relay Plate SPST N.O.	Leach Type 321, Coil 912.

Detail No.	Stock No.	Description	Mfr. & No.
		OTHER COMPONENTS	
L101, L102	3-6203	Inductor 10 H, 200 MA Filter Choke	Osborne #5701
L103	3-5888	Inductor 10 H, 50 MA, 500 Ω, Filter Choke	Triad C-3X
M101	15-5962	Meter 1 MA, Special Scale	Simpson Model 1027
S101	12-5961	Switch 3/8" Shaft, Miniature Steatite, 2 Gang, 2 Poles Total, 10 Pos., Non-Shorting	Centralab PA-2005 Type
T-101	6-5889	Transformer Plate	Wahlgren #2403
T102	6-5890	Transformer Filament	Wahlgren 2402


T102
+130
L101
T101
V101
5V4G
2.5 VRMS CT
6.3 VRMS CT
6.3V
2A
200 MA
C101
V102
6080
R104
R106
R103
I102
'ON'
NE SI
R101
PLUG
V103
5Y3
L102
10H
125Ω
V104
6080
R116
C105
V105
12AT7
C116
20
R118
R115
R114
R119
R112
R113
R117
T102
5V@2A
5V@2A
6.3V@0.9A
6.3V
@2.5A
6.3V
@7.2A
6.3V
@1.8A.
L103
330V RMS
50 MA DC
CR101
6MI
CR102
6MI
CR103
6MI
R127
C114
V106
5687
R120
R121
R122
POWER GND
330V RMS
25 MA DC
CR103A
16J1
CR104
16J1
R128
R137
C115
V108
5687
R129
R130
R131
J106
CONVENIENCE
OUTLET
FILAMENT
F102
2A 125V
SLO-BLO
B101
115V
FAN MOTOR
C110
C111
V111
0B2
V112
0B2
C112
-465V
CR105B
16J1
CR106
16J1
R136
R138
R139





NOTE:
ALL RES. ½ WATT 10% UNLESS OTHER WISE NOTED
CAPACITOR VALUES IN μf.

LOT 1
ISSUE A
7-13-55

Model 1015 Schematic

INSTRUCTION MANUAL

Model 1048
OPERATION AMPLIFIER

BERKELEY division
Beckman Instruments, Inc.

Richmond 4, California
30 November 1955

WARRANTY

Every instrument manufactured by the BERKELEY division of Beckman Instruments, Inc. is warranted to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes, fuses and batteries, which shall within one year from date of shipment to the original purchaser prove to be defective after our examination.

Instruments to be repaired must be returned to the factory with transportation charges prepaid. Repair work will be performed only upon receipt of a written purchase order or authorization. Repaired instruments will be returned to the purchaser with transportation charges collect.

Claims for damage in shipment should be filed promptly with the transportation company. All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing.

Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, BERKELEY division of Beckman Instruments, Inc., Richmond 4, California.

Model 1048 Amplifier

DESCRIPTION

The Model 1048 Operational Amplifier is a chopper stabilized d-c type offering the foremost in accuracy, quality, flexibility, and convenience. Its extremely high gain and low drift, together with plug-in mounting, make it ideal for analog computer use. Ten Model 1048 amplifiers can be plugged into the Model 1041 Operational Amplifier Panel. The Model 1041 supplies plate and filament voltages and contains circuitry for balancing the amplifiers and indicating overloads.

SPECIFICATIONS

D-C drift after Warm-up (Referred to summing junction	Average per hour: Less than 30 μv Average per day: Less than 100 μv Average drift of unity integrator is less than 0.1 v per hour at output.

Gain

D-C Amplifier	Above 100,000
Stabilizing Amplifier	1,000 from d-c to .005 cps
Total	Above 10^8 at d-c
Variation with output voltage	Constant at d-c over full operating voltage range.

Frequency Response

When connected as a unity inverter with 1 megohm input and feedback resistances, the amplifier behaves as a second order linear system with a natural frequency of 20 kc, a damping ratio of 1/2 and a phase shift of about 10^o at 4 kc.

Summing Junction Error Current	Less than 100 $\mu\mu$ amperes
Noise Level	Less than 5 mv referred to summing junction.
Output	
Type	A voltage 180^{o} out of phase with the input
Voltage Range	± 125v maximum ± 100v normal
Maximum Power	15 ma at 100 volts
Impedance at d-c	Below 0.01 ohms
Power Requirements (Furnished by Model 1041)	
Regulated d-c	+250v, 16 ma plus load current
	-250v, 2 ma plus load current
	-465v, 4.5 ma
Regulated a-c	6.3 volts, 60 cps, 1.3 amps
Non-regulated a-c	6.3 volts, 60 cps, 0.6 amps
Tube Complement	One each: 12AU7, 12AY7, 12AX7, 6U8, 12AT7, 5963, Chopper (Stevens Arnold type D-11)
Dinensions	5 3/8" high, 3 1/8" wide, 6 1/2" deep
Weight	2 lbs.

INSTALLATION

Each Model 1048 amplifier is shipped with a clamp on the chopper mounting to protect the chopper during shipment. The clamp may be removed after installing the computer. If the clamp is retained, it should be kept insulated from the chopper shell. The chopper shell is internally connected to signal ground but the clamp is at power ground. Insulation between the two will avoid connecting signal ground to power ground at this point. See the installation section of the computer manual to learn how to connect a Model 1041 panel in an EASE computer. The amplifiers are throughly checked and adjusted before shipment. After a check of power supply voltages they should be ready for operation.

OPERATION

To place the amplifier in operation apply power to the filaments, wait one-half minute, then apply plate power. Allow the amplifier to warm up half an hour before balancing it or using it in a problem-solving circuit. (If the filaments have been energized for some time, a 15 minute warm-up under plate power is sufficient.) When plate power is applied the overload indicator may light and remain lit for a minute or two while the amplifier stabilizes. This is normal. However, an indicator which remains lit indefinitely indicates a faulty amplifier.

Below the number of each amplifier on the panel is a two-position lever switch. When this switch is in the ON (up) position the input and output terminals of the amplifier are connected to the set-up panel and other control system circuitry, and the amplifier may be inserted in a problem-solving circuit if it is properly balanced.

Front Panel Balance or "Zero" Adjustment

This adjustment corrects for amplifier drift and provides an indication of the operating condition of the amplifier. Although daily drift is negligible under normal conditions, daily adjustment is suggested since the procedure is quick and easy and will enable the operator to detect faulty amplifiers before they are used.

To balance an amplifier place all lever switches at ON (up) except the switch belonging to the amplifier to be adjusted. Move this switch to the down (balance) position. Then, adjust the screwdriver control above it until the front panel meter reads zero. This indicates that the output voltage is zero (at ground) with the input at ground. If the meter will not come to zero the amplifier is defective and should not be used in a problem-solving circuit. If the balance adjustment is insensitive compared to that of other amplifiers, the amplifier may lack enough gain to perform properly. When a defective amplifier is left in the computer rack and energized along with the rest, make sure that a feedback resistor (100K to 1M) is connected between the amplifier output and the input grid. This will prevent the amplifier from overloading and actuating the alarm circuitry on the control system. All amplifiers used as summers have a feedback resistor connected under all conditions. The other amplifiers may require a resistor patched in on the set-up panel.

CAUTION: Take care not to connect the amplifier output to ground, since this will damage the output tube. Do not connect a patch cord from the AMP OUT terminal to the AMP GRID terminal on the Model 1022 patch board because the AMP GRID terminal is grounded during some computer operations.

When the lever switch is in the balance (down) position the input and output of the amplifier are disconnected from the set-up panel and connected as follows:

1. Input to ground thru 1 K resistor.
2. Output to front panel meter
3. Output to input through 1 megohm feedback resistance.

This arrangement yields a summing amplifier with a gain of 1000. Since the input resistor is grounded, the output voltage is 1000 times the drift or offset voltage. The front panel meter is calibrated to indicate the offset voltage referred to the summing junction. The meter has a usable indicating range of $\pm 100 \mu$volts.

METHOD OF STABILIZATION

When the input voltage of a d-c amplifier is kept constant, the output voltage changes with time from the original value to some other. This phenomenon, called drift, is caused mainly by changes in B+ and heater voltages, variations in resistor values, tube aging and grid current changes. In a multistage d-c amplifier drift occurring in an early stage causes a greater change in the output voltage than the same drift in a later stage because the early drift is amplified by the gain all succeeding stages. If drift can be eliminated from the first stage the output drift will be reduced in proportion to the gain of that stage. If the gain of this stage is considerable, the output drift will be reduced to a small fraction of its former value.

The first stage of the Model 1048 is an essentially drift-free amplifier with a gain of 1000. Figure 1 is a simplified diagram of the circuit. The chopper is simply a SPDT switch which switches back and forth at the line frequency of 60 cps. It alternately grounds the input and the output of the a-c amplifier. The resulting amplifier input is a square wave with one peak at ground potential and the other at a positive or negative voltage proportional to the summing junction voltage. The output of this capacitor-coupled amplifier is a greatly amplified square wave. The action of the chopper (which grounds the output during one half of each cycle) places one peak of the amplified square wave at ground.

This wave is then filtered by R_2 and C_2 to produce an average d-c voltage proportional to the d-c input but of the opposite polarity. R_1 and C_1 form a filter which prevents 60 cps noise at the summing junction from reaching the a-c amplifier and producing a change in the d-c output level.

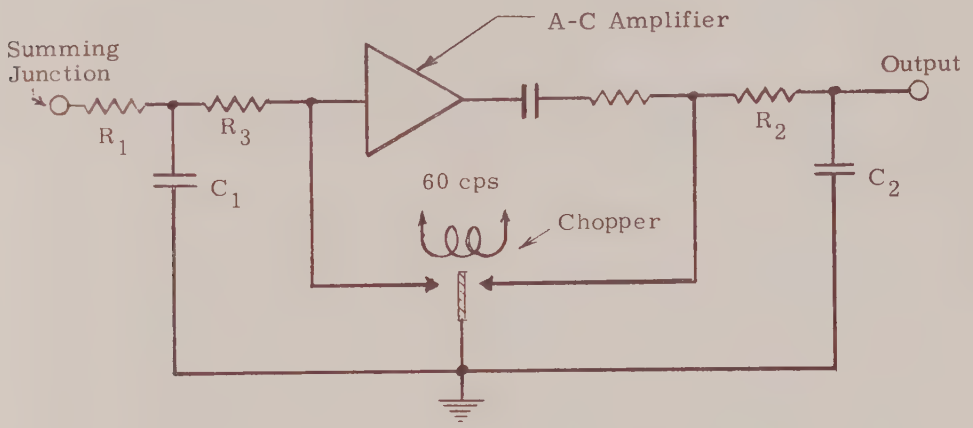


Figure 1 Simplified Diagram of Stabilizing Amplifier

Figure 2 is the frequency response curve of the stabilizing amplifier. Notice that the gain is nearly constant at 1000 from d-c to about .005 cps. At this point the gain begins to decline at 6 db per octave until at 10 cps it is -6 db. Beyond 10 cps the gain declines at 12 db per octave.

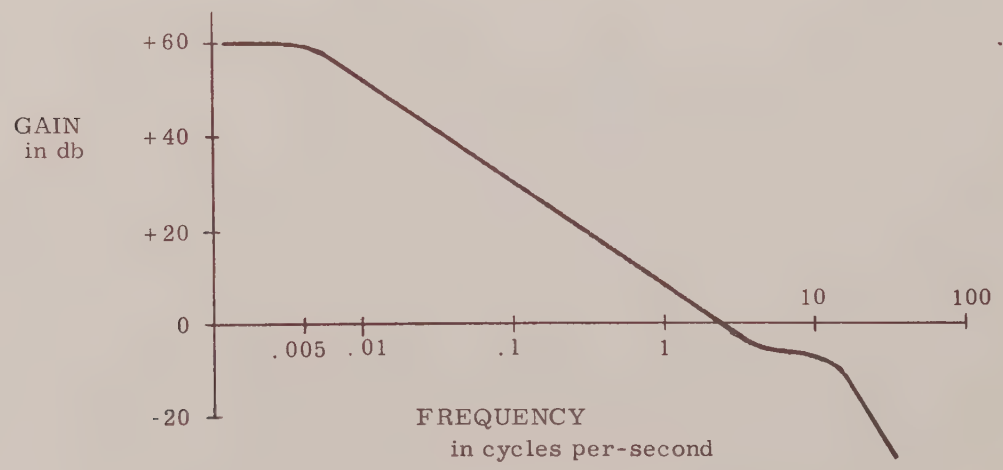


Figure 2 Frequency Response of Stabilizing Amplifier

Figure 3 shows the way the stabilizing amplifier fits into the rest of the Model 1048. The object of this arrangement is to combine the advantages of a drift-free first stage with the broad frequency response of a d-c amplifier. The input signal follows two paths: One directly to the d-c amplifier input, the other through the stabilizing amplifier to the d-c amplifier. The total gain of the Model 1048 is A_2 $(1+A_1)$ where A_2 is the gain of the d-c amplifier (about 100, 000) and A_1 is the gain of the stabilizing amplifier. At drift frequencies (from d-c to .005 cps) A_1 is about 1000, and the stabilizing amplifier functions as a first stage. Above .005 cps its gain declines progressively until at higher frequencies this stage is effectively out of the circuit. The dotted lines in Figure 3 shows the way input and feedback resistances are connected when the Model 1048 is used as a summing amplifier.

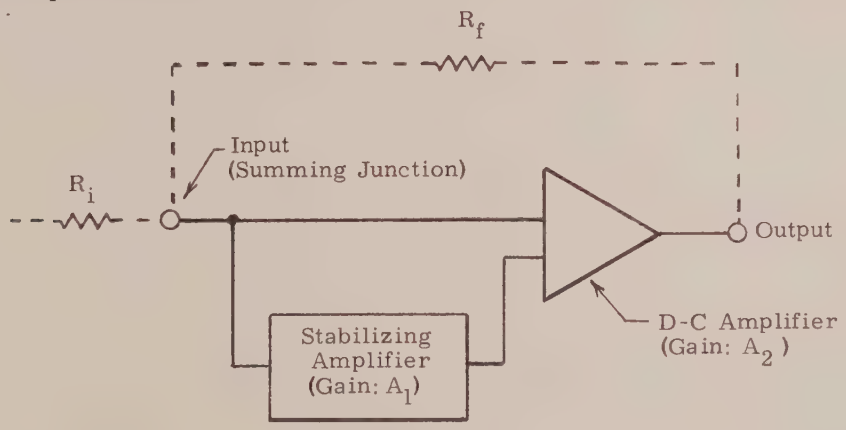


Figure 3 Model 1048 Block Diagram

CIRCUIT DESCRIPTION

The total Model 1048 circuit is shown in the accompanying schematic diagram. V101, the input cathode follower, is operated at very low plate voltage and current in order to keep the grid current less than 100 $\mu\mu$a. C102 couples frequencies above the range of V101 directly to the input of the next stage. The second stage (V102A & B) is an amplifier with positive feedback adjusted to provide "infinite" gain at d-c. This adjustment is described in the maintenance section. The resistor and capacitor (R106 and C102), in series between

the plate of V102-A and ground, form a stabilizing network which controls the frequency response and phase shift of this stage. Following the second stage is another stage of amplification (V103-A) which in turn drives the single-ended push-pull output stage (V103-B and V104 A & B). The chief advantage of this type of output circuit is its very low quiescent plate current. This results in a much higher efficiency for a given load than can be obtained with conventional pentode or cathode follower output circuits.

By confining the positive feedback portion of the circuit to the second stage (V102-A, and B) it is possible to keep the gain very high because the unfedback gain is very constant due to the small swing of the plate voltage. As a result, the output linearity of the Model 1048 is about 0.01% for an overall gain of ten (R_f / R_i = 10) and the output impedance is less than 0.01 ohm below 0.005 cps.

The stabilizing amplifier is the circuit between R118 and C111. The grid of the cathode follower (V105-B) connected to C111 is equivalent to the second input of the d-c amplifier of Figure 3. The output impedance of the cathode follower in series with the coarse and fine zero adjustment potentiometers, all in parallel with the cathode impedance of V102-A, form part of positive feedback network of the infinite gain stage. R108 in series with R109 is the other portion.

The amplitude of the square wave at the output of the a-c amplifier is limited by the capacitor C114 and the selenium diodes CR101 & 2 before it reaches the output filter (R132, R133 and 1 C111). If this were not done the filter capacitor C111 would be over-charged during overload and greatly increase the recovery time of the whole amplifier after the overload was removed. This limiting action reduces the recovery time and, in addition, protects the output chopper contacts from excessive voltages.

The series resistor and capacitor combination (R131 and C110) shunting the filter at the output of the stabilizing amplifier critically damps the response of the system. This minimizes the transient response time of the a-c amplifier and increases its stability.

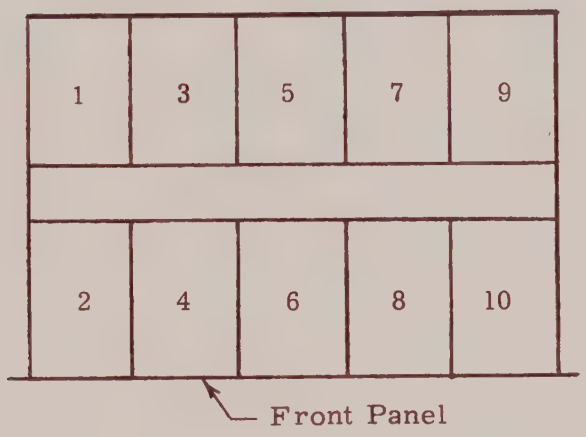
If, due to an overload, summing junction voltage exceeds about 15 millivolts, the amplitude of the square wave at the plate of V106-A becomes very large compared to its amplitude under normal conditions. The diode pumping circuit associated with V106-B responds to this increase in amplitude by increasing the grid bias on V106-B and raising its plate voltage. Referring to the Model 1041 schematic, notice that this increases the voltage across the overload indicator lamp (located on the Model 1041 panel) until it lights. When the summing junction voltage exceeds about 20 millivolts the bias on the 12AU7 (V101 of the 1041) is removed causing it to conduct and energize relay K101. This action in turn can be made to put the computer in a "hold" condition and at the same time operate an audible overload alarm. Since all of the overload indicating lamps have one side connected together, the overload circuit operates when any one of the lamps fires.

The over-all performance of the amplifier when connected as a unity inverter approximates that of a 2nd order system with a damping ratio of about .05 and a natural frequency of about 20KC. Figures 4 and 5 show the relationship between gain and frequency and between phase shift and frequency in the circuits diagramed there.

A .001 μf capacitor (C101) is connected within the amplifier between the summing junction and ground. In case the cable connecting the amplifier to the set-up panel is extraordinarily long, this capacitor may be removed to compensate for the capacity of about 20 feet of cable. The amplifiers are stable even if the summing junction capacity is as high as 0.01 μf, which is the capacity of 200 ft. of cable having a capacitance of 50 $\mu\mu$f per foot.

MAINTENANCE

The diagram below shows how the Model 1048 amplifiers are arranged in the Model 1041 panel. The amplifiers are numbered from 1 to 10. The number of each amplifier appears above the front panel controls associated with it.



TOP VIEW OF MODEL 1041 PANEL

When an amplifier fails to operate properly in a problem-solving circuit, check it first by trying the balance adjustment. If the amplifier balances and shows normal sensitivity, the trouble may be outside the amplifier. The fault may lie in any of three locations:

1. In the amplifier itself.
2. In the circuitry between the amplifier and the set-up panel (relays, connectors, etc)
3. In the patch board connections which have been made. To test the third possibility, patch in an amplifier from some other Model 1041 panel in place of the amplifier which seems to be causing trouble. This substitutes a different amplifier and different connecting circuitry in the problem-circuit. If the trouble persists, the patch board connections are probably wrong. To test the second possibility, remove the suspected amplifier from the Model 1041 panel and replace it with a properly operating Model 1048. If the trouble persists now it is probably due to a defect in the connecting circuitry. If the

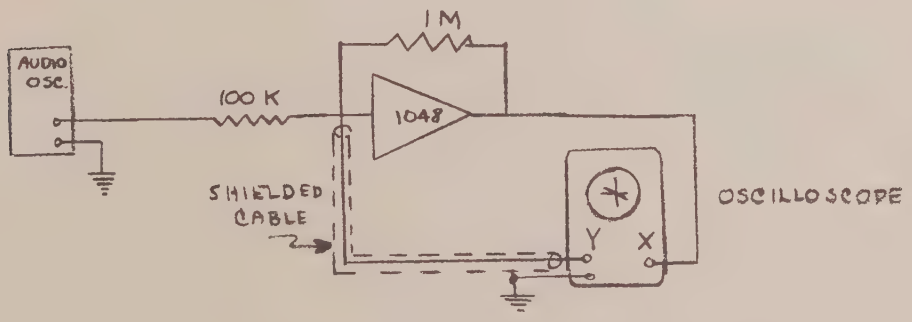
trouble clears, search for a fault in the Model 1048 which was removed. The following adjustment and test procedures will help locate the source of trouble within an amplifier.

Equipment required:

Oscilloscope - 25 mv/in. (e.g. Du Mont 304-A) or 5 mv / cm (e.g. Tektronix 512)
Audio oscillator - 20 cps to 50K cps
Vacuum tube voltmeter - 10 megohms input resistance (e.g. Shasta 201)
Test Cable - Berkeley Model 1048T or equivalent.

Internal Balance and Gain Adjustments

1. Install the amplifier in a 1041 panel and make connections on the set-up panel which form the circuit diagramed below



2. Set oscillator to 45 cps and output to zero voltage.
3. On oscilloscope set Y (vertical) amplifier to minimum gain on a-c and the X (horizontal) amplifier to full deflection at about 200 volts peak-to-peak.
4. Set the front panel balance control halfway between the extremes of rotation. Place the toggle switch beneath this control in the balance (down) position. Adjust the COARSE ZERO control on the top of the Model 1048 chassis until the front panel meter reads within 100 μ volts of zero.
5. Increase output of oscillator until oscilloscope pattern (should be a

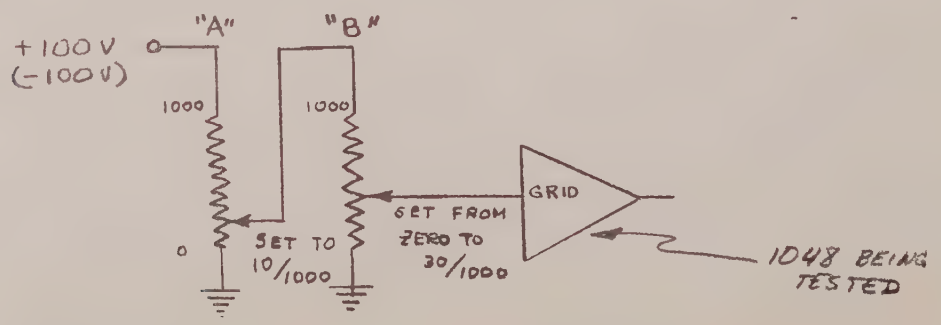
horizontal line) extends across tube face.

6. Increase gain of Y amplifier to ma ximum and, adjust the GAIN control on the Model 1048 chassis until the general slope of the pattern is horizontal. The multiple tract pattern is due to 60 cps noise and is normal. It is the general (average) slope that is to be considered. See sketches below:

7. Since the GAIN and COARSE ZERO adjustments interact slightly it may be necessary to repeat each until both show the proper results.

Stabilizing Amplffier Test

1. Remove amplifier from 1041 panel socket and remove V102 (12AX7), V103 (12AT7), V104 (12AU7) and front and side covers.
2. Connect the amplifier to the panel socket with the Model 1048T test cable. This cable merely extends the socket terminals so that the amplifier may be tested in a convenient location. The cable also carries a toggle switch for applying and removing plate voltages and test point jacks connected to the summing junction and amplifier output points. Wait one minute after the amplifier is connected and filaments energized before applying plate voltages with the toggle switch.
3. Connect the amplifier at the computer set-up panel as in the diagram below.



4. Connect the oscilloscope Y input to a point connected to pin 4 of the chopper socket. Set oscilloscope for d-c and an amplitude sensitivity of 25 volts / inch. Synchronize the sweep with the a-c line and adjust it to contain four or five cycles of the line frequency. A square wave should appear on the scope.

5. Vary potentiometer "B" between 0 and 30. This varies the summing junction voltage from zero to 30 millivolts. At 30 millivolts the wave on the scope should reach an amplitude of about 25 volts. Reversing the polarity of the voltage at the input of potentiometer "A" should produce an equal but inverted pattern. C114, CR101 and CR102 limit the amplitude of the square wave. The overload indicator on the 1041 panel should light when the summing junction voltage reaches about 20 mv.

6. Measure the voltage at Pin 8 of V102. This should be about 3 volts when the summing junction voltage is zero and rise smoothly as the summing junction voltage is increased.

Amplifier Load Test

1. Connect a 6,700 ohm resistor (at least 2 watt) from the amplifier output to ground on the set-up panel.

2. With amplifier connected as either a summer or integrator adjust the input voltage to cause output voltage to rise to +100 and -100 volts.

3. The output should reach ±100 volts or more before the amplifier overloads. If the amplifier overloads below 100 volts check V103 and V104.

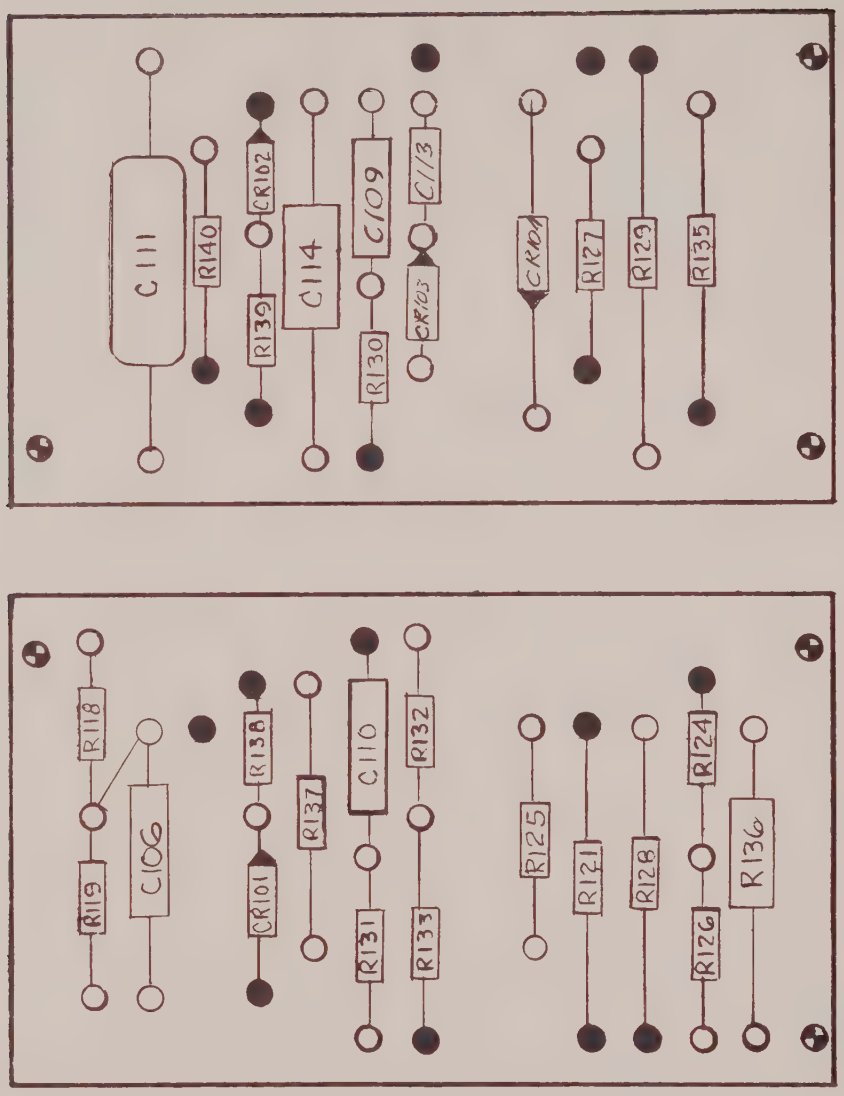


Figure 6 Model 1048 Parts Location Diagram

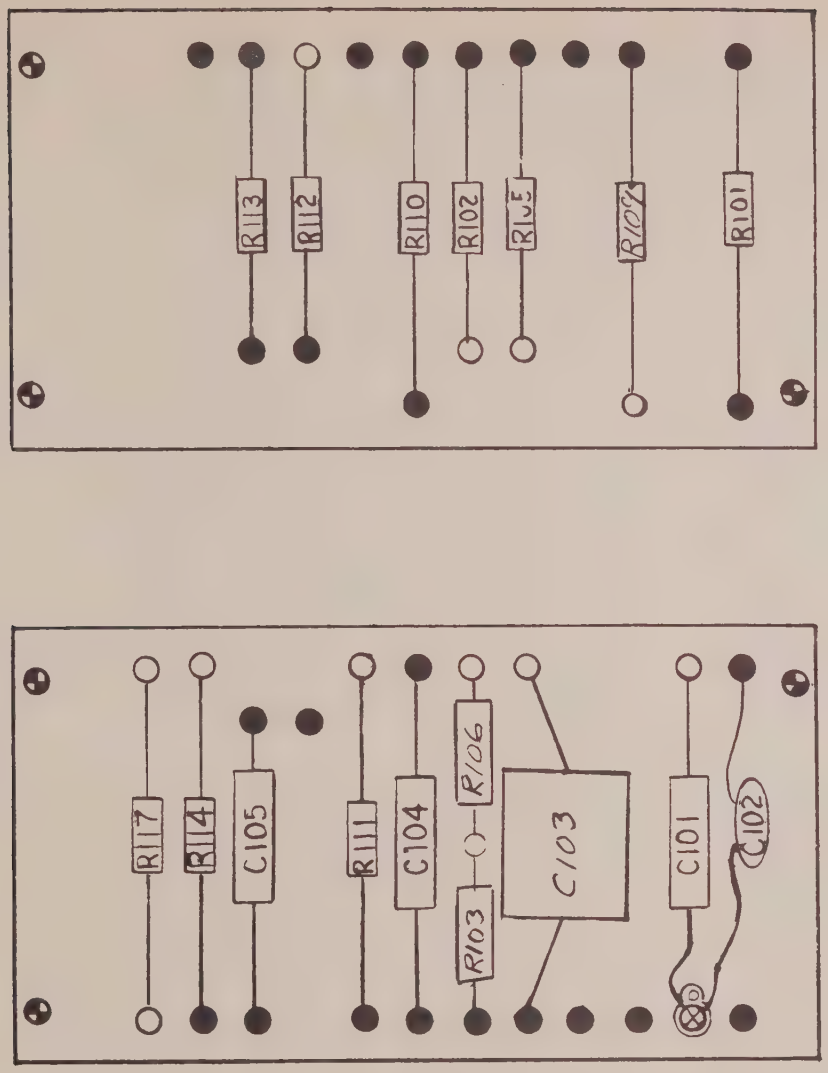


Figure 7 Model 1048 Parts Location Diagram

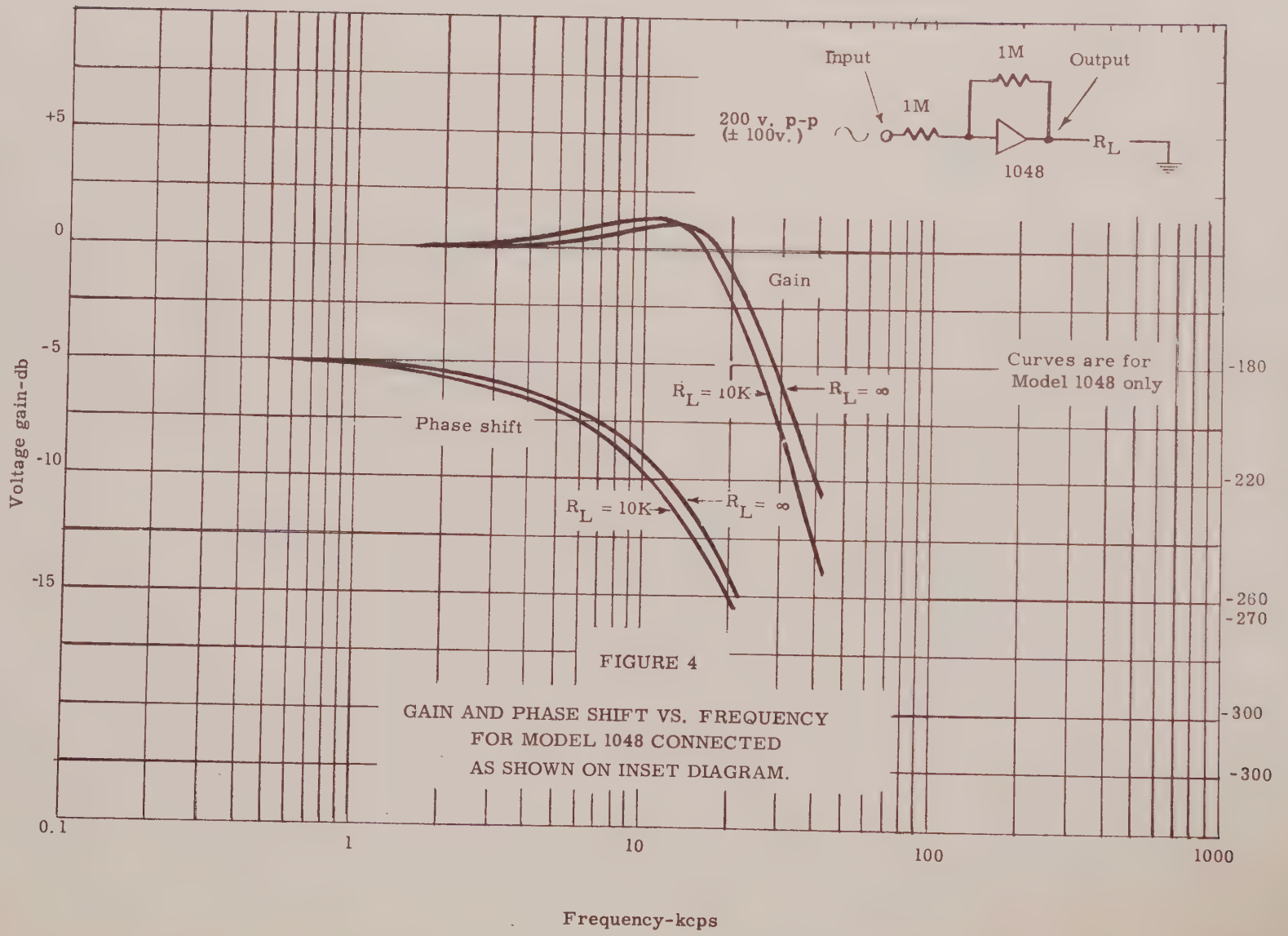


FIGURE 4

GAIN AND PHASE SHIFT VS. FREQUENCY
FOR MODEL 1048 CONNECTED
AS SHOWN ON INSET DIAGRAM.

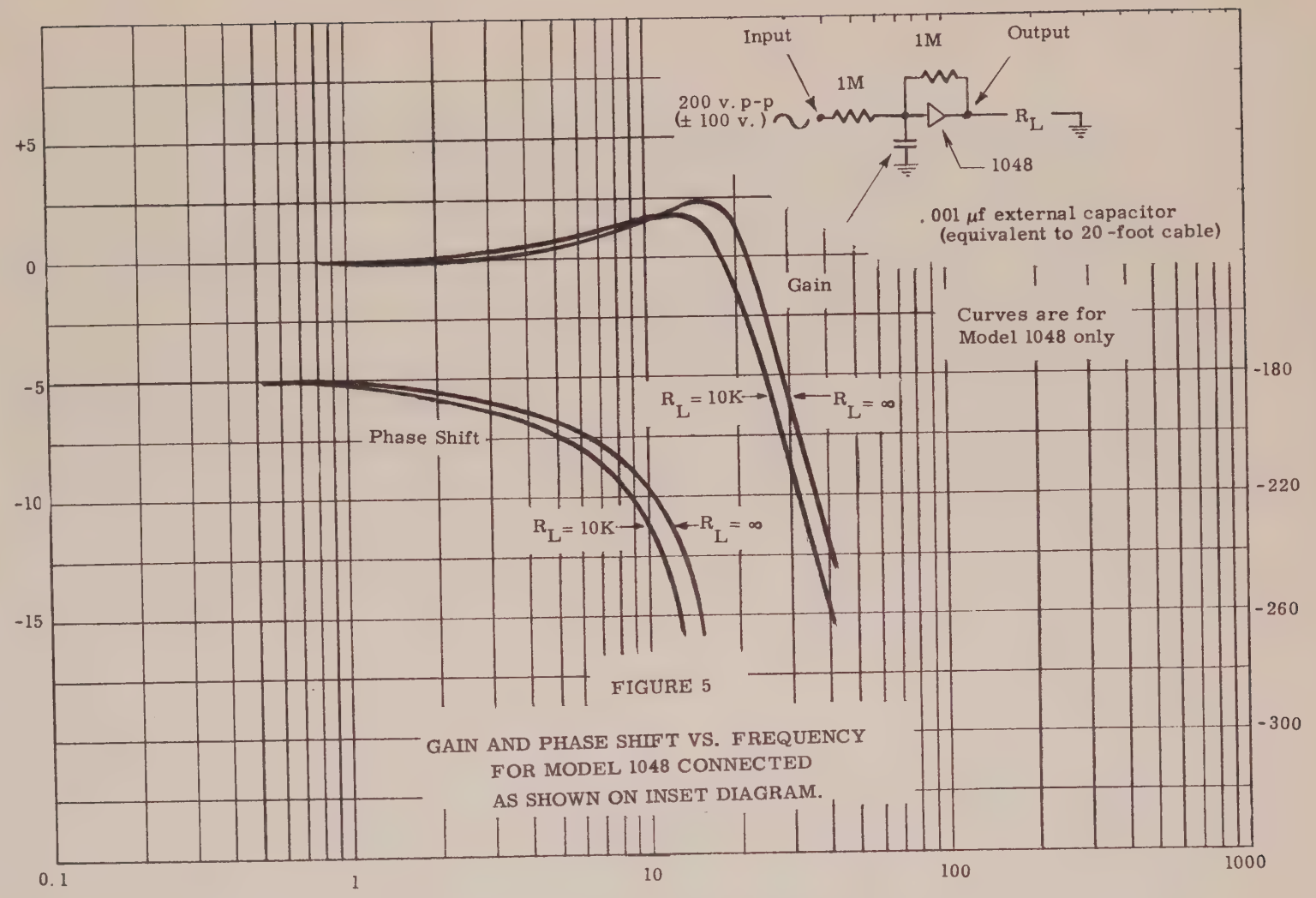


FIGURE 5

GAIN AND PHASE SHIFT VS. FREQUENCY
FOR MODEL 1048 CONNECTED
AS SHOWN ON INSET DIAGRAM.

MODEL 1048 PARTS LIST

TUBES

Type	Quantity	Type	Quantity
5963	1	12AU7	1
12AX7	1	12AY7	1
12AT7	1	6U8	1

Detail No.	Stock No.	Description	Mfr. & No.
		RESISTORS	
R101	1-1178A	4.7 M, 1/2W, 5%	AB EB 4755
R102	1-1208	180 K, 1/2W, 5%	AB EB 1845
R103	1-1169A	18 K, 1/2W, 5%	AB EB 1835
R105	1-0225A	1 M, 1/2 W, 5%	AB EB 1055
R106	1-0209A	1 K, 1/2W, 5%	AB EB 1025
R108	1-5692	500 K, 2 W, Linear Potentiometer	AB JU 2541-SD 3032
R109	1-0214	47 K, 1/2W, 5%	AB EB 4735
R110	1-0798A	1.5 M, 1/2 W, 5%	AB EB 1555
R111	1-1182	10 M, 1/2 W, 5%	AB EB 1065
R112	1-0215A	56 K. 1/2W, 5%	AB EB 5635
R113	1-2183	3.5 M 1 W 1 % D. C.	Electra
R114	1-3375	2.0 M, 1/2 W, 1 % D. C.	IRC
R115, R116	1-2396	6.8 K, 1/2 W, 5%	AB EB 6825
R118		Same as R110	
R119		Same as R113	
R120		Same as R111	
R121	1-0220	220 K, 1/2 W, 5%	AB EB 2245
R124	1-3609	3.9 K, 1/2 W, 5%	AB EB 3925
R125	1-1856	470 K, 1/2 W, 5%	AB EB 4745
R126		Same as R111	
R127		Same as R105	

Detail No.	Stock No.	Description	Mfr. & No.
R128	1-0376	270 K, 1/2 W, 5%	AB EB 2745
R129		Same as R109	
R130		Same as R105	
R131, R132	1-5768	22 M, 1/2 W, 5%	ABE B 2265
R133			
R135	1-0228A	2.7 M, 1/2 W, 5%	AB EB 2755
R136		Same as R121	
R137	1-0223	560 K, 1/2 W, 5%	AB EB 5645
R138, R139	1-0312	22 K, 1/2 W, 10%	AB EB 2235
R140		Same as R137	
R141	1-1174A	150 K, 1/2 W, 5%	IRC
R142	1-5065	Potentiometer 5 K, 2 W, WW	Clarostat Series 43
R143	1-0210A	10 K, 1/2 W, 5%	AB EB 1035
R144		Same as R105	

CAPACITORS

C101	2-1760	.001 µfd, ± 20%, Mica	Sangamo K1210
C102	2-2230	.01 µfd, Disc.	Erie #811
C103	2-2915	2500 µµ fd, 500 V, 10%	Sangamo C1225
C104		Same as C101	
C105	2-2607	33µµfd, Mica	Sangamo RR
C106, C107	2-4187	.01µfd,	Gudeman XF-2207-10
C108, C109	2-3899	.01µ fd, 400 V, 10%	Gudeman XF-1819-10
C110		Same as C101	
C111	2-5707	.68 µfd, Tubular Paper 10%	Gudeman XGS 2118-10
C112		Same as C102	
C113	2-2137	500µµfd, Mica	Sangamo RR 1350
C114	2-3086	.1µfd, 400 V, Tubular Paper, 10%	Gudeman XF1816-10
C115	2-2082	10 µµ fd, ± 1 µµ fd 500 V	Sangamo RR 1410
C116	2-2095	10µ fd, 25 V DC	Sangamo MMT-0210
C117	2-2136	100 µµfd, Mica	Sangamo RR 1310

OTHER COMPONENTS

Detail No.	Stock No.	Description	Mfr. & No.
CR101 & CR102, CR103 CR104	8-2986	Selenium Diodes	Inter. Rectifier 1U1
K101	16-5695	Chopper Electro-Mechanical SPDT, M-B-B Action	Stevens-Arnold #D-11
P101	17-5694	Connector 14 Pin Male, Chassis Mtg.	Elco Varicon M11450-3

MODEL 1041 PARTS LIST

TUBES

Type	Quantity
12AU7	1

RESISTORS

Detail No	Stock No.	Description	Mfr. & No.
R101	1-5733	270 K, 1 W, 5 %	AB GB 2745
R102	1-1101	82 K, 1/2 W, 5 %	AB EB 8235
R103		Same as R101	
R104	1-0217	100 K, 1/2 W, 10%	AB EB 1041
R105	1-1174	150 K, 1/2 W, 10%	AB EB 1541
R106	1-0209A	1 K, 1/2 W, 5 %	AB EB 1025
R107	1-5853	100 K, 1 W, 1 %	SW- 1B Allow E Cinema
R108	1-2329	Potentiometer 500 Ω, 2 W Linear	AB JU 5011 SD 3048
R109	1-0225A	1 M, 1/2 W, 5 %	AB EB 1055
R110	1-0011B	10 K, 2 W, 5 %	AB EB 1035

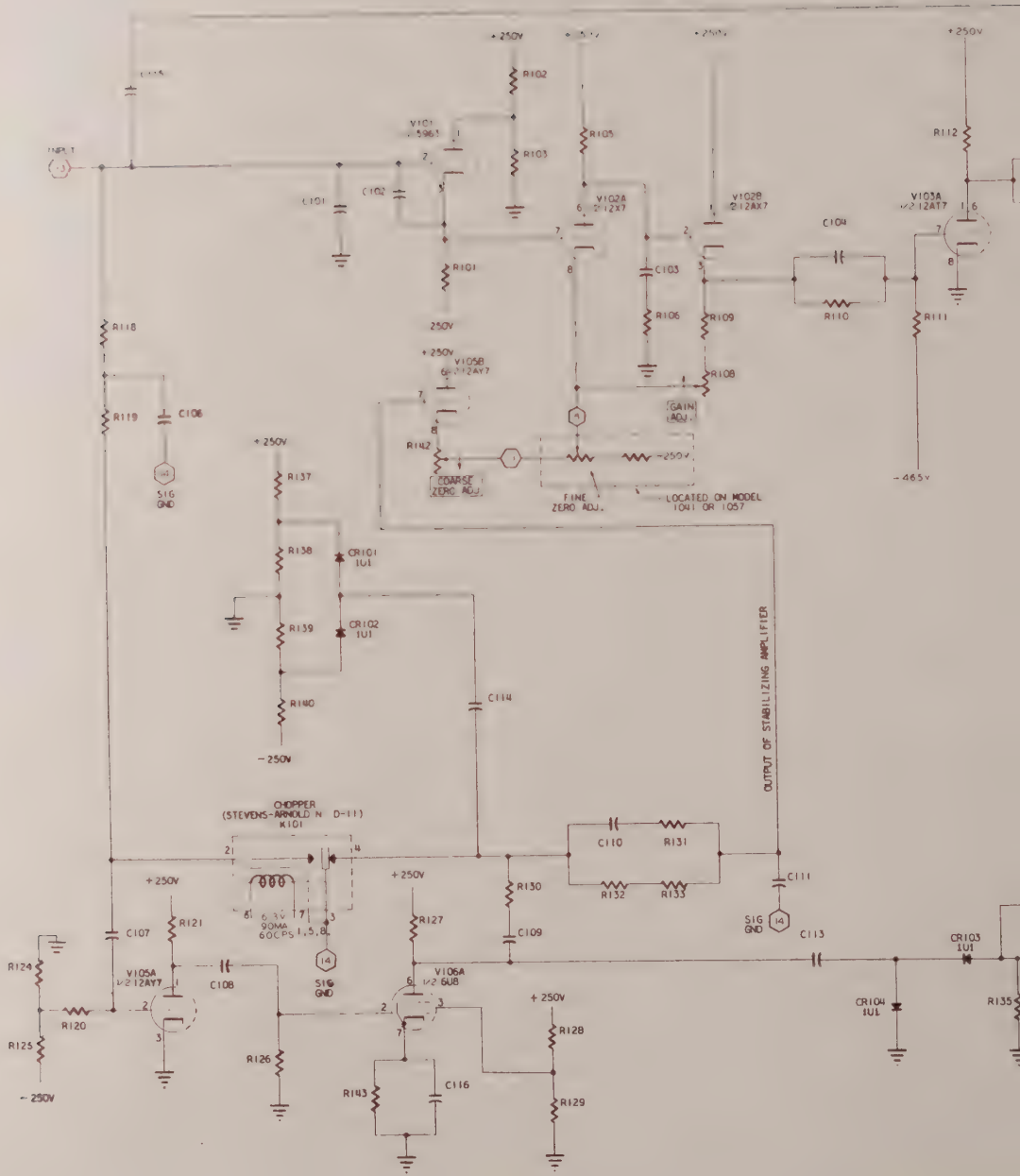
CAPACITORS

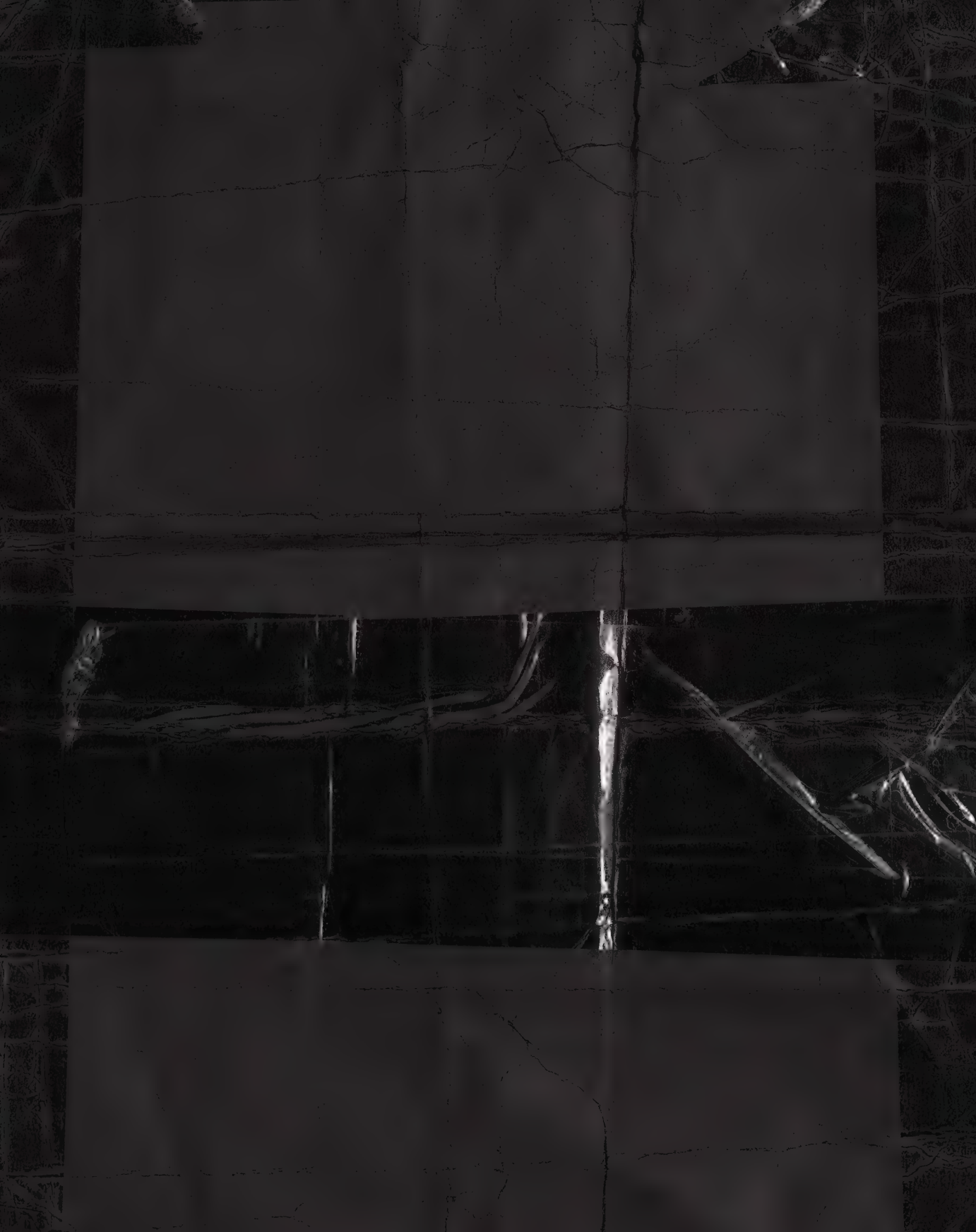
C101, C102	2-0763	.1 μfd, 400 V, Molded Paper	Sangamo Type 30, 300401
C103	2-2230	.01 μfd, Disc	Erie Type 811

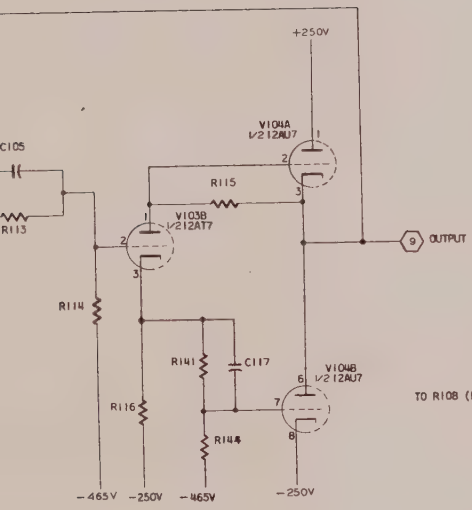
OTHER COMPONENTS

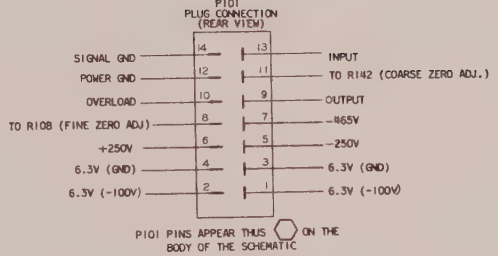
B101, B102	9-3390	Fan Motor	General Industries A5-CW

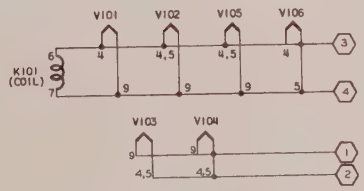
Detail No.	Stock No.	Description	Mfr. & No.
CR101 & CR102	8-5870	Diode Germanium Junction	Raytheon CK 739
F101	7-0504A	Fuse 2 Amp SLO BLO	LittleFuse 313002M
F102	7-5883	Fuse 1 Amp, 125V SLO BLO	LittleFuse 313001
I101	21-1679	Neon Lamp NE51	GE NE 51
J102	17-6403	Connector Ruggedized Female Varicon, 28 Contact Chassis Mtg.	Elco Varicon, RF22850-1
K101	16-1865	Relay Plate SPST N.O.	Leach Type 321, Coil 912
M101	15-5871	Meter -100/0/+100 Micro A	Simpson 1027
P101	17-5732	Connector Male Varicon, 6 Contact w/hood	Elco Varicon, M10654
S101	12-5803	Switch	Switchcraft 6S-1245
T101, T102 T103	6-0917	Transformer Filament 6.3V 8 A	UTC FT-8
T104	6-2979	Transformer 120V A Capacity	Sola Type 2, Cat # 30806
XAY101	17-6402	Connector Female Ruggedized Varicon, 14 Contact Chassis Mtg.	Elco Varicon, R F11450-3

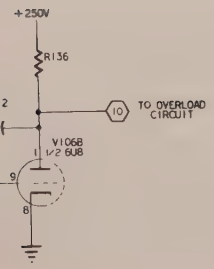

+250V
R102
R103
V1C1
5963
R105
V102A
12X7
V102B
12AX7
R112
V103A
12AT7
C104
R110
R111
C103
R106
R109
R108
R101
250V
C101
C102
INPUT
R118
R119
C106
SIG GND
V105B
12AY7
GAIN ADJ.
R142
COARSE ZERO ADJ.
FINE ZERO ADJ.
-250V
LOCATED ON MODEL 1041 OR 1057
-465V
R137
R138
CR101 1U1
R139
CR102 1U1
R140
-250V
C114
OUTPUT OF STABILIZING AMPLIFIER
CHOPPER (STEVENS-ARNOLD N D-11) K101
6.3V 90MA 60CPS
C110
R131
R132
R133
C111
SIG GND
C113
CR103 1U1
CR104 1U1
R135
R130
C109
R127
C107
R121
C108
V105A
12AY7
V106A
12 6U8
R124
R120
R125
R126
R143
C116
R128
R129











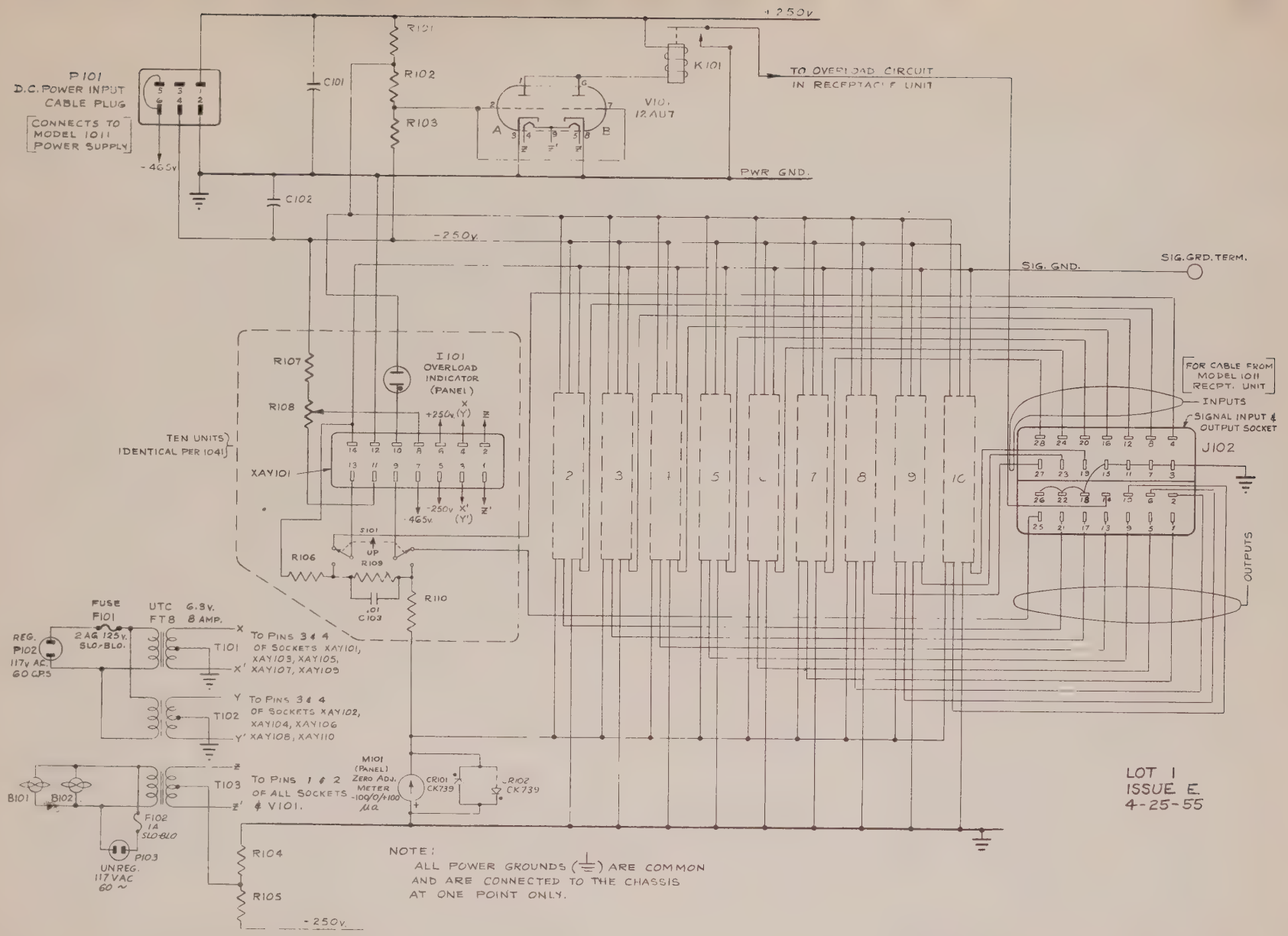
NOTE:

RESISTORS:
WATTAGE ——— ½W UNLESS OTHERWISE NOTED
TOLERANCE ——— 10% UNLESS OTHERWISE NOTED
CAPACITORS:
CAPACITORS: ——— IN μf UNLESS OTHERWISE NOTED

⏚ ——— POWER GROUND
⬡ ——— PIN CONNECTION P101

LOT 10
28 SEP 56

Model 1048 Schematic



Model 1041 Schematic

summer, 1956

introducing

NEW BERKELEY

INSTRUMENTS and COMPONENTS:

- FERRISTORS*
- DECIMAL COUNTING UNITS
- COUNTERS & PRESET COUNTERS
- TIME INTERVAL METERS
- EPUT* (Events-Per-Unit-Time) METERS
- UNIVERSAL EPUT* METERS
- FREQUENCY METERS
- NUCLEAR SCALERS, COUNT RATE METERS
- NUCLEAR AUTOMATIC SAMPLE COUNTERS

*EASE** COMPUTERS

*EASE** COMPUTER-QUALITY CONTROL SYSTEM COMPONENTS

Systems for:

- DATA REDUCTION
- DATA HANDLING
- DATA LOGGING
- INDUSTRIAL MEASURING & RECORDING
- INDUSTRIAL PROCESS CONTROL

*Trademark

BERKELEY
SHORT FORM CATALOG
C 703

Berkeley division of Beckman Instruments Inc.

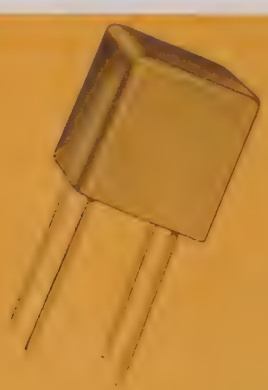
FERRISTORS* for Magnetic Amplifier and Counter Circuitry

FERRISTORS* are reliable, light weight, low-power replacements for tubes consisting of simple wire-wound coils on ferro-magnetic cores, and encapsulated in epoxy resin. They are immune to damage by shock, vibration, overload, humidity or temperature, and are ideally suited for industrial electronics where long-term reliability is an important factor.

In BERKELEY's new line of long life counter-controllers, FERRISTORS* are used to perform all the functions of vacuum tubes in input amplifier, gate, time base, decimal counting unit, coincidence amplifier and control circuitry.

Complete technical data and prices will gladly be supplied on request.

Compact FERRISTOR* is encapsulated in 9/16" cube, with 4 pigtail leads.



VACUUM TUBE Decimal Counting Units

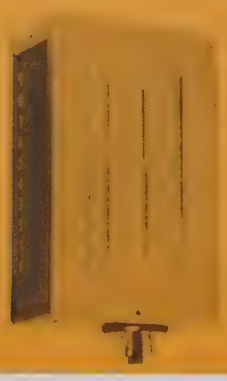
All DCU's are designed for a four-line binary coded output to drive Berkeley digital printers, remote in-line readouts, or data converters. Counts are displayed in digital form on the illuminated front panel; units may be cascaded to provide any desired total count capacity, and plug into standard sockets.

Model 705AH—100 kc max. count rate. Price, $33.00.

Model 707AH—1 mc max. count rate. Price, $95.00.

Model 711AH—2 mc max. count rate. Price, $110.00. Designed to drive 713AH (200 kc count rate, $75.00) which in turn drives the 705AH.

MAGNETIC Decimal Counting Units



Models 716-717 Magnetic DCU measure only 1⅞" x 5½" x 3½". Model 716 has 10,000 cps max. counting rate; Model 717, 40,000 cps. Price (either model), $110.00.

Model 736 Dual Preset Magnetic DCU produces output signal at any two presettable counts, handles up to 10,000 cps. Measures 1⅞" x 5½" x 3½". Price, $130.00.

Magnetic DCU's are capable of counting up to 40,000 pulses a second. Units may be cascaded indefinitely to achieve a counter of any capacity. Each DCU counts from 0 to 9, presenting an illuminated reading on the front panel.

Elimination of vacuum tubes permits an overall size reduction of up to 32% and a weight reduction of up to 59% over other units. Illustrated magnetic DCU's are plug-in units fitting standard octal sockets. Lower heat generation resulting from decreased power requirements permits more compact assembly than vacuum tube types.

VACUUM TUBE Preset Decimal Counting Units

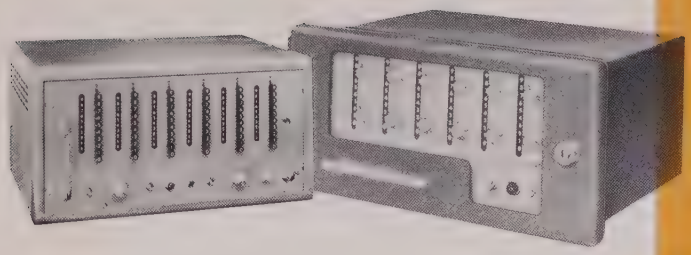
Model 730A Single Preset DCU produces output pulse at any single preset count. Price, $65.00.

Model 732A Dual Preset DCU produces output pulses at any two preset counts. Price, $75.00.

Berkeley Single and Dual Preset Counters count and display information at rates to 40,000 cps, and produce output pulses at any preset total count (Model 730A) or any two preset counts (Model 732). Output pulses will operate relays, audible or visual signals, solenoids, etc.

*Trademark

PRESET COUNTER-CONTROLLERS

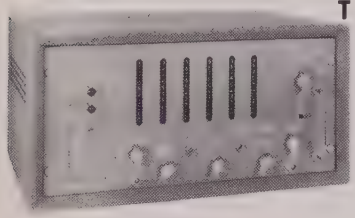


Count at rates to 40,000 cps, produce output signals at any desired preset total (or any two preset counts with dual preset models). Operate on input pulse of ± 1 volt peak, or more. Instantaneous reset to zero after final count. Reliable, simple to operate. Available in 2,3,4,5 and 6-digit capacities. Long-life magnetic Model 5840 dual preset features FERRISTOR* circuitry for continuous-duty reliability.

Series 5420 single preset models range in price from $435.00 for 2-digit capacity to $740.00 for 6-digit capacity. Dual preset Series 5440 range from $560.00 (2-digit) to $840.00 (6-digit).

Series 5840 long-life magnetic dual preset counter features FERRISTORized* circuitry; 6-digit, Model 5846, $1,295.00.

TIME INTERVAL METERS



Model 7250 Berkeley Time Interval Meters provide a direct, digital reading of elapsed time between any two events, or the duration of a single event, in microsecond (Model 7260) or 10-microsecond increments.

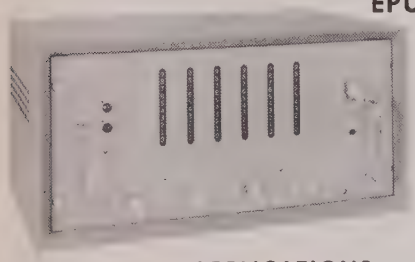
Any occurrences that can be changed to varying voltages may be so timed. Both models may be standardized against WWV or other external standards, and have connections for driving digital printers or data converters. Provisions are also made to measure period of input signals or use as a high-speed electronic counter or frequency ratio meter.

APPLICATIONS

Timing of relays, shutters, solenoids, controls; ballistics research; measurement of viscosity; elasticity, velocity; accurate low frequency and period measurements; calibration of pulse generators, precision phase measurements, frequency ratio measurements, etc.

BRIEF SPECIFICATIONS	Model 7250	Model 7260
Range:	10 μ sec to 1 sec	1 μ sec to 1 sec
Accuracy:	$\pm$ 10 μ sec, $\pm$ 1 part in 10^5	$\pm$ 1 μ sec, $\pm$ 1 part in 10^6
Input Requirements:	0.1 v rms, 10 megohms, ac or dc—coupled	
Display Time:	Adjustable, 0.1 to 5 seconds (automatic reset) Manual reset also provided.	
Price: (f.o.b. factory)	$595.00	$830.00

EPUT* (Events-Per-Unit-Time) METERS

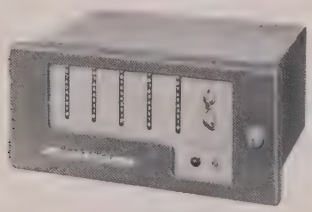


APPLICATIONS

Precision tachometry; measurement of pressure, flow, temperature, viscosity, velocity, frequency, frequency period; process control or data reduction systems; calibration of frequency generating equipment; measurement of any electrical, mechanical, optical or other physical event occurring during a precise time interval.

Berkeley EPUT* Meters automatically count and display the number of events that occur during a precise time interval. Events may be any physical occurrences that can be represented by changing voltages occurring either regularly or at random at rates to 1,000,000 per second, depending on model.

7000 Series units may be used to measure frequency or period, and also as high speed electronic counters with manual on-off control.



Model 7650 Long-Life Magnetic EPUT* Meter

BRIEF SPECIFICATIONS

	Model 7150	Model 7160	Model 7650
Count Capacity:	5 digits	6 digits	5 digits
Count Rate:	0 cps to 100 kc	0 cps to 1 mc	0—40,000 cps
Time Bases: (decade steps)	10 μ sec to 1 sec	1 μ sec to 1 sec	0.1 to 10 sec
Price:	$775.00	$995.00	$1,495.00

Performs the same function as models described above. Employs Berkeley FERRISTORS* in all critical circuits to assure continuous-duty reliability. Ideally suited to industrial test applications such as jet and piston-engine test cells, etc. Has digital "count-down" time base for precise gating; no adjustment of time base required.

*Trademark

MODELS 7350 and 7360 UNIVERSAL EPUT* METERS

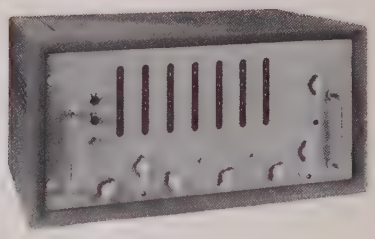
APPLICATIONS

Counting, time interval, EPUT* measurements for precision tachometry, measurement of pressure, flow, frequency, velocity, viscosity, elasticity; timing relay, shutter action, etc.

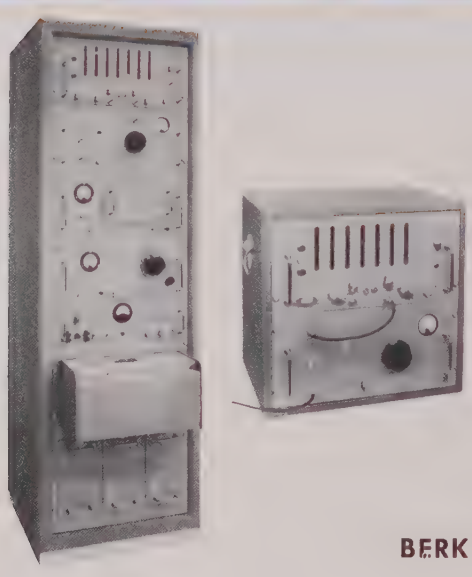
Measurement of unknown frequencies, frequency ratios, periods, etc.

BRIEF SPECIFICATIONS

	Model 7350	Model 7360
Ranges-Frequency:	0 cps to 100 kc	0 cps to 1 mc
Time Interval:	10 μ sec to 10^6 sec	1 μ sec to 10^7 sec
Period:	0 cps to 100 kc	0 cps to 1 mc
Time Bases:	10 μ sec to 10 sec	1 μ sec to 10 sec
Price:	$890.00	$1,175.00



These truly universal instruments combine high-speed electronic counting with a precision time base in multi-purpose circuitry. They function as counters, timers, time-interval meters, EPUT* meters, frequency, frequency ratio or period meters, or as secondary frequency standards.



Frequency Meters and Frequency Measurement Systems

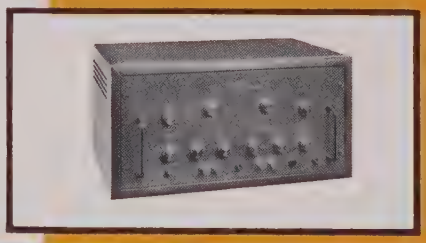
Basic instrument is the Model 5571, capable of measuring frequencies from 0 cps to 42 mc. Addition of the Model 5580 UHF-VHF converter and suitable plug-ins extends the range to 515 mc; Model 5582B VHF converter with plug-ins extends the range to 1,000 mc. Results are displayed in direct-reading digital form. Unit will drive a Model 1452 digital printer to provide a complete frequency logging system in which results are printed on standard adding machine tape. Model 5571 is also a Universal EPUT* and Timer with same specifications as Model 7360.

Model 5571 with 5580 converter and 5580 series plug-ins for frequencies to 515 mc. Model 5571 price, $1,745.00. Model 5580 converter, $300.00; 5581 series plug-ins, $100 to $150.00 each. All are FCC-approved.

Complete frequency logging system for frequencies to 1,000 mc. Model 5571 (with 5582B converter and plug-ins), drives Model 1452 digital printer to record results automatically on adding machine tape. 5590 WWV receiver and 5585 2 to 42 mc Selective Amplifier also shown.

BERKELEY DOUBLE PULSE GENERATORS

Produce paired or single pulses. Pulse amplitude, width, polarity, repetition rate and pulse-to-pulse spacing are independently adjustable. Outputs may be mixed internally or externally. Model 903 ($440.00) can be driven externally by pulses; Model 4904 ($595.00) by pulses or sine wave generators.



BERKELEY TEST ACCESSORIES

TACHOMETER PICKUPS

Consist of magnetic pickup and toothed tachometer gear (number of teeth optional). Offered in 3 types, also explosion proof. Photocell pickups and light sources also available.

MODEL 1452 DIGITAL PRINTER

Connects directly to any Berkeley 5510, 5571 or 7000 Series instrument, prints data in digital form on standard adding machine tape. May be modified to print "Time" or "Code" information simultaneously with data. Rack mounted; available in up to 8 digits. Price (6 digit), $850.00.

MODEL 5916 IN-LINE READOUT

Large, illuminated in-line IN-PLANE figures reduce fatigue and error. Ideal for remote observation of data. Connects directly to any Berkeley 5510, 5571 or 7000 Series instrument. Price (6 digit) $775.00.

*Trademark

FIELDS OF ACTIVE PARTICIPATION

1. High speed, high accuracy analog-to-digital and digital-to-analog conversion
2. Digital timing and recording systems
3. Automatic logging systems (static or dynamic)
4. High speed telemetered data handling
5. Industrial tachometry-fuel flow measuring and recording systems
6. Complete closed loop analog control systems
7. Industrial batching-sorting control systems
8. Automatic nuclear sampling and recording systems
9. Special-purpose digital computers
10. General-purpose data handling and data reduction systems
11. Machine tool control

Telemetered Data Handling Systems

Among recent systems developed by Berkeley is one capable of high speed measurement and recording of FM and FM-commutated data. Analog data represented by a frequency-modulated signal is continuously decommutated, measured, operated on, and the corrected data presented at the output in both digital and analog form. Features include:

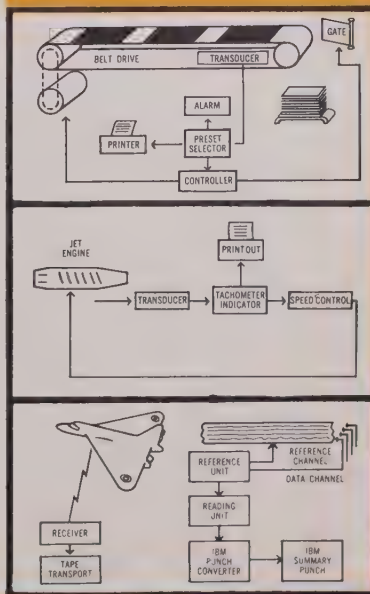
1. Compensation for tape wow and flutter
2. Compensation for transducer drifts
3. Accuracy to $\pm$ 0.1%
4. High speed digital computation

Other systems can be provided for pulse code telemetering, featuring an airborne electronic commutator, a reliable airborne magnetic analog-to-digital converter, and on-line computation of data on the ground.

Standard component blocks have also been developed for use in telemetering systems handling Pulse-Width and Pulse-Amplitude modulated signals.

Typical Systems

1. Steel mill counter-controller. Counts, stocks, batches and records steel sheets. Eliminates costly give-away.
2. Jet engine tachometer controller. Measures high rotational speeds to an accuracy of 0.001%.
3. Tape-data-to-punch-card system. Reduces multiple channels of magnetic tape data to punch cards; does in 30 minutes a task that formerly required 80 hours.



Model 5692 Digital Flow Indicator

Automatic Logging Systems

Berkeley division has long been actively engaged in the investigation and manufacture of complete data handling systems. The approach used is to accumulate standard blocks which can be assembled into a complete system to meet individual customer requirements.

Both dynamic and static logging systems can be provided for the sampling and recording of temperature, pressure, RPM, fuel flow, position and other analog quantities.

Speed of sampling may range from 1 sample per second to 40,000 samples per second with accuracies to ± 0.1%. Inputs can be from thermocouples, strain gages, or digital transducers.

Typical systems include either mechanical or electronic commutator, analog to digital converter, programmer, output storage unit and recording device.

Timing and Recording Systems

With the use of modified digital time interval meters and digital recorders, as manufactured by Berkeley division, complete industrial timing and recording systems can be manufactured to meet individual requirements.

Timing accuracies to ± .1 microsecond can be provided with recordings on standard adding machine tape, paper punched tape, magnetic tape, IBM cards, typewriter, teletype machine, by the use of Berkeley data reduction converters which operate with all Berkeley instruments.

Model 5692 Digital Flow Indicator provides four-digit presentation, reading directly in pounds or gallons per hour either as a flow indicator or totalizing meter. Works with any digital flow meter.

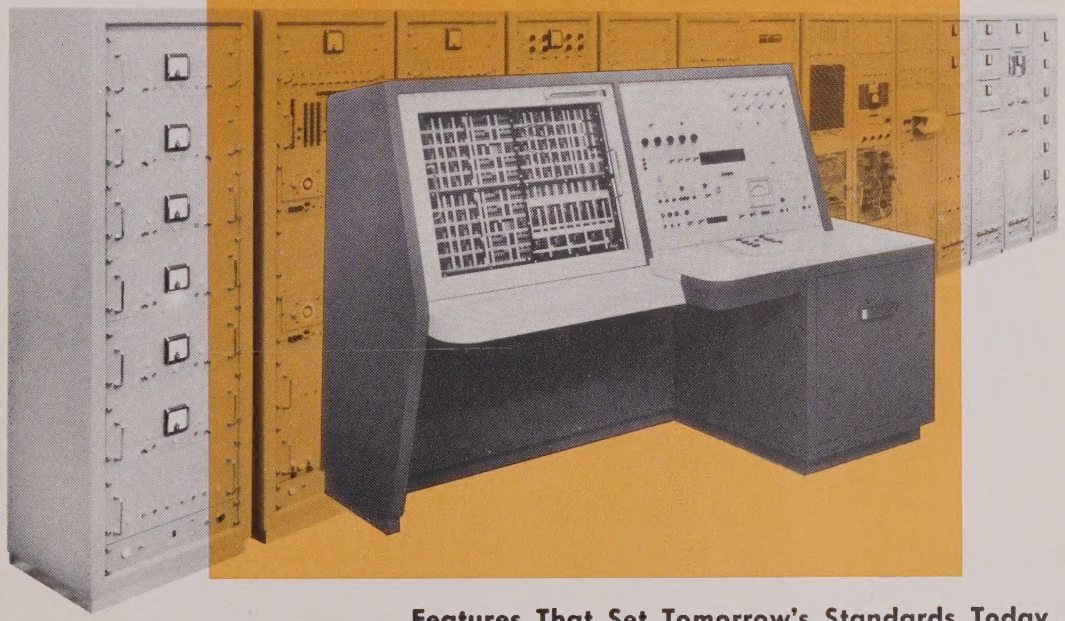
Automatic Nuclear Sample Counter automatically counts and records data on printed tape; handles up to 250 samples. Berkeley's complete line of Nuclear instruments includes decimal scalers, count rate meters, scintillation counting systems.

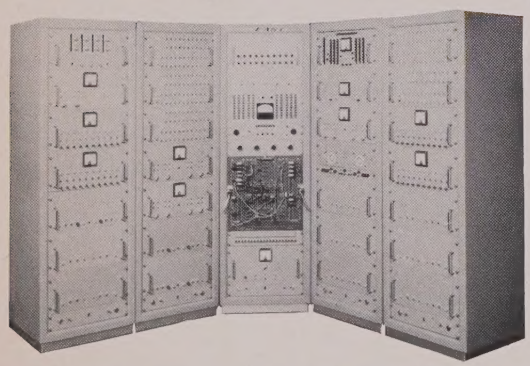
New *EASE** 1200 Series Analog Computers

The EASE* 1200 series represents maximum convenience and accuracy in large scale analog computers, including completely automatic and/or remote control of all attenuator settings by a serial type keyboard and/or punched tape input. In the EASE* 1200, the user finds tomorrow's computer today.

The patch bay system is all new, featuring complete shielding and insulation to eliminate accidental shorting of patch cords. The patch bay has sufficient capacity (3600 terminals) to interconnect more than:

- **100 dc amplifiers**
- **16 servos**
- **350 keyboard-controlled attenuators**
- **30 electronic multipliers**
- **250 spare terminals**
- **Adequate trunk lines and terminals for limiters, biases, etc.**





MEDIUM-PRICED — .05% accuracy; includes pushbutton control unit to handle up to 100 servo-set pots, 50 amplifiers, 16 electronic multipliers. Various combinations of function generators, servo multipliers and special equipment available.

Features That Set Tomorrow's Standards Today

1. **High accuracy and stability**
2. **Complete keyboard control of all problem parameters including initial conditions and coefficients**
3. **Automatic punched tape or card attenuator setting**
4. **Complete and automatic recording of all problem parameters**
5. **Built-in problem checking system**
6. **Built-in 6-channel chart recorder**
7. **Completely shielded patch cord and patch board system**
8. **"Human engineered" centralized console design**
9. **Instantaneous and "stored" overload indication**
10. **Unitized design for complete flexibility and future expansion**
11. **Modular construction**

LOW-PRICED — 1% accuracy; as shown includes 10 amplifiers (stabilized or unstabilized), 16 coefficient pots, 10 initial condition voltages for integrators. Model 1031 patch board accommodates up to 42 decade stepping resistors and multiturn pots, 30 amplifiers, for future expansion.

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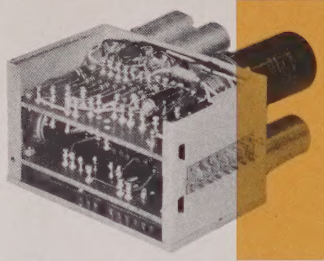
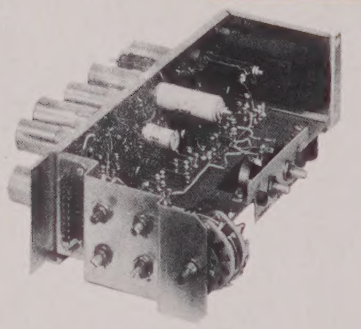
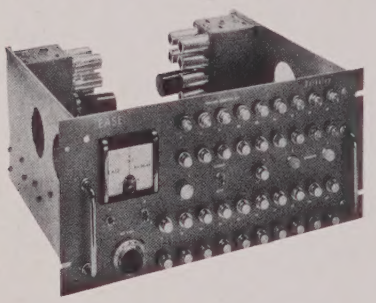
*EASE** Computer-Quality Components for Control Systems



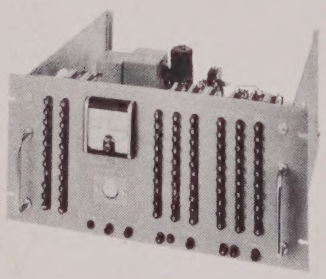
Model 1048 DC Amplifier... a chopper-stabilized operational amplifier with open loop gain in excess of 10^8 and extremely low drift. Adaptable to many computing functions where accuracy and stability are important such as amplification, inversion, addition or integration. These amplifiers have also been used as isolation devices, as highly stable recorder drives, as difference amplifiers, etc.



Model 1056B Electronic Multiplier... a highly stable device with less than 0.2% drift in any 8-hour period, static accuracy of 0.2% of full scale, and frequency response flat within ½ db to 500 cps. Useful wherever accurate, fast multiplication of dc voltages is desired at reasonable cost.



Model 1073 Function Generator... a self-contained diode function generator requiring no patching or external connections. Approximates non-linear function by 20 straight-line segments, using locking-type knobs for adjustments, accurate null-reading meters, and precision potentiometer. Can be used for linearizing outputs of transducers or non-linear metering devices, to compensate for non-linear values or transfer characteristics in process control, or for simulating characteristic behaviour of physical systems.



Automatic Setup Function Generator... completely self contained diode function generator; one control unit sets up to 10 function generators automatically. Can be used in combination with a Berkeley servo as a "mapreader" to generate functions of two variables.

Complete technical data price and delivery information on any Berkeley product will gladly be supplied on request. Call your nearest Berkeley representative (listed below), or write us now; please address Dep't G13.

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